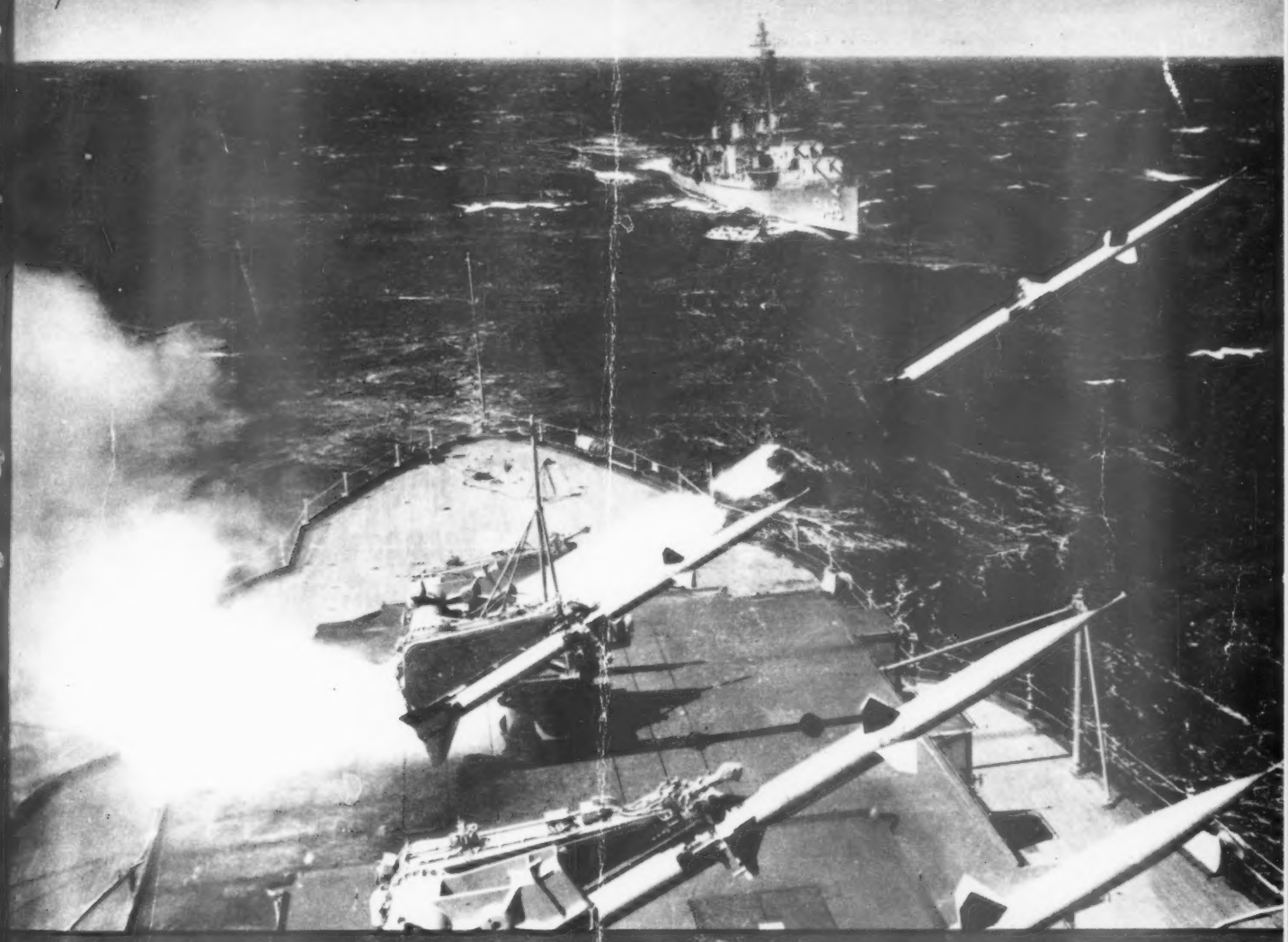
Spaceflight

ENGINEERING
TK
785
.A1
S18
v.1
no.2

UNIVERSITY OF MICHIGAN
FEB 27 1957
ENGINEERING LIBRARY



VOL. I No. 2

CONTENTS

JANUARY 1957

PROGRESS WITH VANGUARD	A. V. Cleaver
OPERATION MOONWATCH	W. H. Haas
THE MOON—THE EARTH'S NEAREST NEIGHBOUR	E. A. Whitaker
GODDARD, FATHER OF MODERN ROCKETRY	G. V. E. Thompson
OERLIKON ROCKETS	M. F. Allward
THE SEVENTH INTERNATIONAL CONGRESS OF ASTRONAUTICS	R. A. Smith
THE ROME CONGRESS: TECHNICAL REPORT	G. V. E. Thompson
THE V-2 POWER PLANT	A. V. Cleaver
SKY DIARY, JANUARY TO MARCH, 1957	Patrick Moore
A TRIBUTE TO A. M. LOW	P. E. Cleator

REVIEWS

BIS

PRICE 3/-

PUBLISHED BY THE BRITISH INTERPLANETARY SOCIETY

COVER

TERRIERS, BUT NOT PETS!

A Terrier guided missile roars off the deck of the USS Mississippi as three others rest on launching platforms during evaluation tests last Spring. Nearby is the USS Krause. Releasing this photo in Washington on Dec. 6, the Navy said it had been held up previously for security reasons.

SPACEFLIGHT

Volume 1 **JANUARY 1957** **Number 2**

★ ★

PAGE

Editorial 45

PROGRESS WITH VANGUARD. By A. V. CLEAVER.

The latest news about the Earth Satellite programme; developments which have taken place in recent months 47

OPERATION MOONWATCH. By W. H. HAAS.

What will the Earth Satellites look like? Will they be visible without telescopes? How they will be tracked by visual means, and what amateur observers can do to help 49

THE MOON—THE EARTH'S NEAREST NEIGHBOUR. By E. A. WHITAKER.

The lunar world; its nature, its features, and the conditions which we must expect to meet upon its surface 52

GODDARD, FATHER OF MODERN ROCKETRY. By G. V. E. THOMPSON.

The life and work of the great pioneer who fired the first of all liquid-fuel rockets.. 61

OERLIKON ROCKETS. By M. F. ALLWARD.

Some of the high-altitude rockets produced by the Arms Division of this famous Swiss firm .. 64

A TRIBUTE TO A. M. LOW. By P. E. CLEATOR 70

THE SEVENTH INTERNATIONAL CONGRESS OF ASTRONAUTICS. By R. A. SMITH.

A personal account of the Congress of the I.A.F., held in Rome in September, 1956 71

THE ROME CONGRESS: TECHNICAL REPORT. By G. V. E. THOMPSON.

Some of the important researches which were described by delegates to the I.A.F. Congress .. 77

THE V-2 POWER PLANT. By A. V. CLEAVER.

A concise description of the power plant of the German V-2, the first of the really successful high-altitude liquid-fuel rockets.. 84

SKY DIARY, JANUARY TO MARCH, 1957. By PATRICK MOORE.

What to look for in the night-sky during the early months of the New Year 86

REVIEWS 88

The British Interplanetary Society

The British Interplanetary Society was founded in 1933 to promote the development of interplanetary exploration and communication by the study of rocket engineering, astronomy and other associated sciences. It now includes among its members many British and foreign workers prominent in these fields.

The Society organizes meetings, lectures, exhibitions and film shows. These programmes are planned not only to assist the spread of technical knowledge, but to stress the limitless possibilities of rocket propulsion, and in particular the ultimate implications to human society of the crossing of space.

The Journal of the Society is published bi-monthly, and is issued free to members. Full particulars of membership can be obtained from the Secretary. The Secretarial Address is: 12 Bessborough Gardens, London, S.W.1; telephone TATe Gallery 9371.

COUNCIL, 1956/7

Chairman:
R. A. SMITH

Vice-Chairman:
L. R. SHEPHERD, PH.D., B.SC.

D. J. CASHMORE, B.SC.
J. FOLEY, B.SC., A.F.R.AE.S., G.M.I.MECH.E.
K. W. GATLAND, F.R.A.S.
S. W. GREENWOOD, B.SC., M.ENG., A.M.I.MECH.E.
J. HUMPHRIES, B.SC., A.M.I.MECH.E., A.F.R.AE.S.
PATRICK MOORE, F.R.A.S.
W. N. NEAT, B.A., A.F.R.AE.S.
A. E. SLATER, M.A., M.R.C.S., L.R.C.P., F.R.MET.S., F.Z.S.
G. V. E. THOMPSON, B.SC., A.R.C.S., A.R.I.C.
H. P. WILKINS, PH.D., F.R.A.S.

Secretary: L. J. CARTER, A.C.I.S.

Branch Secretaries:

Midlands: G. C. Haefeli, B.Sc., Grad. I.Mech.E., 960, Bristol Road, Selly Oak, Birmingham 29.
North-Western: R. G. Boor, 47 Whitegate Road, Chadderton, Nr. Oldham, Lancs.
Scottish: D. Malcolm, 18 Caledonia Street, Paisley, Renfrewshire.
Southern: D. H. Penney, 9 Clifton Road, Millbrook, Southampton.
Western: P. W. Stone, 96 Bromley Heath Road, Downend, Bristol.
Yorkshire: L. S. Strickson, 26 Ripon Road, Harrogate, Yorkshire.

EDITORIAL BOARD OF *SPACEFLIGHT*

Editor: PATRICK MOORE, F.R.A.S.

A. COLEMAN, M.A., F.R.G.S.
C. A. CROSS, M.A.
D. HURDEN, B.A., G.I.MECH.E.
A. E. SLATER, M.A., M.R.C.S., L.R.C.P., F.R.MET.S., F.Z.S.

Opinions expressed in signed articles are those of contributors, and do not necessarily reflect the views of the British Interplanetary Society unless such is expressly stated to be the case.

All material is protected by copyright. Permission for reproduction may be granted only on written application to the Secretary of the Society.

Editorial

Since the publication of No. 1 of *Spaceflight*, several important events have taken place. The Seventh International Congress of Astronautics has been held in Rome; more details have been announced as to the "Vanguard" Earth Satellite programme; preparations have been made with regard to the visual tracking of the satellites when they have been launched; and the planet Mars, having made one of its closest approaches to the Earth, has receded once more, not to be favourably placed again until 1958. Another event, this time a most unhappy one, has been the death of A. M. Low, a former President of the British Interplanetary Society, one of the few well-known scientists who supported us in the dark days when anyone who even dreamed of travelling to the Moon was regarded as an automatic candidate for the nearest mental hospital.

There has therefore been every reason to continue the policy adopted for No. 1, and to make the present issue another "mixed bag". As well as a summary of the recent Vanguard developments, we are glad to include an article about visual methods of tracking the future satellites—an operation known by the picturesque code name of "Moonwatch"—written by one of its organizers, W. H. Haas. Other aspects of rocket research, past and present, are dealt with by A. V. Cleaver and M. F. Allward, while the subject for G. V. E. Thompson's second historical article is that great pioneer Dr. Goddard, whose first feeble liquid-fuel rocket, fired privately over a quarter of a century ago now, may be said to have ushered in the Interplanetary Age.

The Rome Congress has been of particular importance, and it has seemed well worth while to deal fully with it. Our Chairman, R. A. Smith, has described it from the personal point of view, while technical papers have been summarized in non-technical language by G. V. E. Thompson. The papers themselves will of course become available in publications such as the official *Astronautica Acta*, but it is felt that Mr. Thompson's summary will provide a most useful introduction which will be of interest to everybody. One of the problems discussed at Rome was that of "weightlessness"; new facts are now available in the light of very recent research, and these will be discussed by Dr. A. E. Slater in the next issue of *Spaceflight*.

We cannot pass the death of A. M. Low without something more than a mere reference in an Editorial. Surely nobody is better qualified to write an appreciation of him than our Founder, P. E. Cleator, who worked with Low in the early, difficult days.

The time is approaching when rocketry and astronomy must merge into one science, and we must therefore not neglect the astronomical aspect. Our first target must of course be the Moon, simply because it is relatively so near, and this issue includes an introductory article by E. A. Whitaker, fully illustrated by recent photographs. Other lunar problems, such as those of survival on the Moon's surface, will be discussed in forthcoming articles. Mars, despite its close approach, has proved to be rather a disappointment this year from an observational point of view, because conditions in the Martian atmosphere have made the surface features indistinct (even though we can hardly maintain that the "Martians", too, have been having canal trouble!). The full results of work carried out in 1956 will take some time to collect, but will be described in a forthcoming article to be published shortly.

One suggestion made in many of the letters received was that we should print a "sky diary", to enable non-astronomical readers to identify the main objects of the night skies. Since this feature has been requested, it has been included in the present issue; comments as to its scope and desirability will be appreciated.

It seems desirable to say a word or two about some of our contributors. There is naturally no need to stress the parts played in the astronautical movement generally, and in the B.I.S. particularly, by R. A. Smith (present Chairman), P. E. Cleator (Founder), A. V. Cleaver (Past Chairman) and G. V. E. Thompson (member of the present Council); the name of M. F. Allward will also be known to most people, by

virtue of his lectures and of his contributions to the *Journal*. W. H. Haas is one of America's leading amateur astronomers; he is the founder of the Association of Lunar and Planetary Observers, and edits the *Strolling Astronomer*, the official organ of that Society. His services to astronomical science have received official recognition in the United States and elsewhere, and he is one of the organizers of the Moonwatch operation, so that he is singularly well qualified to write about it. E. A. Whitaker has recently succeeded Dr. Wilkins, one of the B.I.S. Council members, as Director of the Lunar Section of the British Astronomical Association. The B.A.A. is widely regarded as the world's leading observational society, and its Lunar Section has done invaluable work in observation of the Moon's surface; Mr. Whitaker has an international reputation in this field, and we are grateful to him for providing so comprehensive an article.

Perhaps I may be forgiven for repeating one paragraph of the Editorial which I wrote for No. 1 of *Spaceflight*:

"Some articles will be commissioned by the Editorial Board, but unsolicited articles will be very welcome. The technical level required can be judged from the papers in this issue. Constructive criticisms are also welcome. If a letter is intended for publication, it should be so marked."

PATRICK MOORE,
Editor.

Glencathara,
Worsted Lane,
East Grinstead,
Sussex, England.

Progress with Vanguard

By A. V. CLEAVER, F.R.AE.S.

The latest news about the Earth Satellite programme; developments of recent months.

For the next two years at least, it seems likely that the main news in astronautics will be concerned with the Earth's first satellite vehicles—first, the American Vanguard and then its Russian counterpart, followed by the more ambitious successors they are both certain to have. After the comprehensive and definitive article by Gatland in its very first issue, *Spaceflight* will of course attempt to record for its readers the progress made on all such projects, together with such comment as may seem appropriate to its contributors.

Throughout the past year, a steady stream of small news items on Vanguard has appeared in such American periodicals as *Time* and *Newsweek*, and the aviation magazines like *Aero Digest*, *American Aviation*, and *Aviation Week*. Until recently, these statements were all of an unofficial character—not for nothing is reference sometimes made to a mythical publication called "Aviation Leak"!—and it was necessary to take some of them with the proverbial grain of salt. Thus, the published suggestion that great anxiety was felt because the motor of the big first stage was deficient in specific impulse was rather implausible, because General Electric were chosen to develop a special version of their earlier Hermes engine to meet this requirement, simply because its specific impulse was a higher percentage of the theoretically attainable figure than anyone else's.

On the other hand, and to continue the proverbial metaphor with a difference, there is no smoke without fire; some of the other published statements suggesting that all was not well with the power plant development sounded much more convincing. For some reason, it is not unusual in the guided missile world for propulsion to be taken much more for granted than is ever justified; everyone worries about guidance and control, but assumes that some variant of an existing motor design will give no trouble at all, or very little. (Perhaps this is because, in general, plumbing looks so very much less impressive, so vastly less scientific, than electronics; even so, one would have expected anyone who has seen a large rocket engine fire to treat such devices with all due respect, not to say awe, and to realize that their development presents severe problems.)

Thus, if the report was true to the effect that great difficulty was being experienced in making the first stage Vanguard motor run for much longer periods than it had had to do, without burning out, in its earlier Hermes version, then we need feel no surprise, nor is this any cause for criticism of G.E. Such experiences are the normal thing in rocket development. Theory may predict that heat transfer is so rapid that conditions stabilize within seconds, so that if a chamber will last for one minute, it will for three; usually this is true, but sometimes nature apparently forgets to tell the engine so, and it melts somewhere, for some secondary reason, after a duration only very slightly increased, or under some conditions of operation which theory had said were not significantly different from standard.

The picture which emerged from all such news stories during the first six months or more of 1956 was of a crash programme being very energetically pursued, proving rather more difficult than some of its sponsors had hoped or expected, but not really providing any surprises, in the snags encountered, for those thoroughly familiar with engineering development. Those who earn their livings this way (there are easier ways) are used to the ever-present risk of gastric ulcer or nervous breakdown, and to the management, government agency, public relations or sales department, which blithely says: "But it *must* be ready! Why, it says here . . . ." The Americans were indeed brave when they announced, in September, 1955, that their first artificial satellite would be established, but definitely, during the I.G.Y. One feels pretty sure that the Russians must be trying equally hard to achieve exactly the same result, but how much wiser they were not to announce such a specific date beforehand! (And, incidentally, how much one wishes that the same snippets of information were available, from which to draw one's own conclusions, on the progress of the Soviet satellite; it is more than likely that the Russian story, if and when it is told, will show an uncanny parallel with the American one.)

This writer hopes, and believes, that the American Vanguard programme will succeed, if not in 1957, then at least in 1958—still within the I.G.Y. The mere fact of the rash announcement, with Presidential authority, that the job would be done then is almost a guarantee that (somehow, and with full use of U.S. resources) it will be. In any case, the more recent news "leaks" have been decidedly more optimistic: *Time* for August 27 even quoted the U.S. Navy's director of the project as stating "It is fair to say that at the moment we see no problem we cannot solve as scheduled".

At the 1956 I.A.F. Congress in Rome, N. E. Felt, Jr., operations manager for the Vanguard project at the Martin Company, told us that the winter of that very year would see the actual launching of some of the vehicles concerned—not, in the first instance, a complete Vanguard assembly, of course. However, in November

it was planned to mount the small solid-propellant Vanguard third stage on top of a Viking, and fire off the combination as a two-step rocket which should reach record heights. Later on, as they became available, preliminary firings would take place of the other Vanguard components, either as separate rockets or in various combinations. Felt also warned that the first launchings of the actual three-stage Vanguard assembly would not be attempts to establish satellite spheres in their proper orbits, but rather, near-vertical shots with special heavy instrumentation to obtain further data on the development of the rocket vehicles themselves. (It would be just as well if the public realize this, so that cries of failure do not arise too soon.)

The most recent rumour about Vanguard to find its way into print (at the time of writing—end of October) is that the U.S. Army hopes to steal a march on this joint-services, but Navy-directed, project, and launch its own satellite sooner. Our contemporary, the U.S. *Missiles and Rockets* magazine, devoted the first editorial page of its first (October, 1956) issue to the discussion of this intriguing possibility, of which *Time* has said:—"Leader of this dark plot, according to rumour, is famed Wernher von Braun, chief creator of the German V-2, now chief of guided missile development at the Army's Redstone Arsenal, Huntsville, Alabama. Von Braun is said to believe that the satellite-launching vehicle should have a more powerful first-stage rocket. The Army has such rockets, notably the mighty Redstone (range: 200 miles plus), and unless stopped by higher authority, Army missile men may try to beat the Navy to space."

Certainly, many of us were surprised when the first satellite project to be officially announced proved to have no more thrust than the Vanguard's 27,000 lb., and (for that matter) a final payload of only some 20 lb. It seemed to be a lot of trouble for a relatively small result, in terms of instrument readings, and to render even that result dependent on small margins of error—the whole Vanguard project calls for very high structural and motor efficiencies, by previous standards. Von Braun's larger Redstone would undoubtedly make a suitable first stage, capable, in combination with other suitable liquid or solid-propellant upper stages, of launching satellite objects at least as large as those contemplated for Vanguard. In fact, it is a frequently-repeated story that just such a combination formed the basis of an earlier official satellite project (see, e.g., the issue of *Missiles and Rockets* already quoted). One day we may know if this was so, and, if it was, whether it was superseded by Vanguard because of some superior technical merit in the Martin Navy project, or because of inter-service politics, or because someone in very high authority decided that the Redstone team was better employed on the development of purely military ballistic missiles.

At any rate, the very real possibility seems to exist of there being, by 1958, *three* satellite rockets—Vanguard, one derived from Redstone, and one from the U.S.S.R.!

Satellite Paradox

Three hundred miles above the surface of the Earth a tiny sphere races along at 18,000 miles an hour in a circular orbit. It is the end product of millions of man-hours of toil, and many millions of dollars. To put it into this orbit some 8 tons of complex and rigidly specified propellants have been burnt in a three-stage rocket, guided by an electronic brain capable of measuring and controlling the missile's speed to the nearest 150 miles an hour, and its direction to within a fraction of a degree.

Three hundred miles up almost the whole atmosphere has been left behind. Each cubic inch of space contains only about ·0000000000000007 ounces of air, compared with ·0007 ounces at sea level. The artificial satellite travels completely around the Earth every 90 minutes, and in each revolution it will collide with ·0003 ounces of air. Everyone can see that this will slow it down by a tiny but definite amount.

Everyone is wrong. The atmospheric resistance will actually cause the satellite to travel faster, although Newton's laws of motion are not contravened. The effect is most simply explained by remembering that the speed in a circular orbit is inversely proportional to the square root of the orbit radius. Thus, when the satellite meets air resistance it loses altitude, and as it spirals down its speed increases steadily until it comes into denser layers which cause its destruction in meteoric fashion. Thus when the first satellite is flown the most important information will be obtained by measurements of its rising speed as air resistance "slows it down". These measurements will fix more closely the air density above 100 miles, which is at present uncertain by a factor of ten.

It is perhaps of interest that this paradox is not new to science, but has long been observed to apply in reverse to our natural satellite the Moon. The force involved here is the gravitational effect of the tides. These are of course raised on the Earth by the Moon, but they produce an equal and opposite force on the Moon which tends to push it on along its orbit. The Moon responds to this force by spiralling slowly away from the Earth, at the same time moving more slowly along its orbit. The changes involved are very slow indeed, but they are detectable. One effect is to lengthen the day by one quarter of a second every century.

C. A. Cross.

Operation Moonwatch

By WALTER H. HAAS

What will the Earth Satellites look like? Will they be visible without telescopes? How they will be tracked by visual means, and ways in which amateur observers can help.

From July, 1957, to December, 1958, many of the leading nations of the world will co-operate in a gigantic scientific effort of remarkable scope, the International Geophysical Year. As a small part of this effort there will be a project especially dear to the hearts of all amateur astronomers and spaceflight enthusiasts: the United States will launch a number of small artificial satellites. These will be spheres about 20 inches in diameter, according to present plans, and will orbit around the Earth a short distance outside its atmosphere. Many of us may thus think of them as Man's first step toward the age-old dream of travel to other worlds. These first satellites, however, will modestly and properly be concerned with study of our own Earth. Precise observations of the position of a satellite can give improved knowledge of the exact size and shape of the Earth, and unknown mineral deposits may possibly reveal themselves through their gravitational effect on the motion of a satellite. The exact density of the atmosphere at elevations of more than 200 miles above the Earth's surface is imperfectly known; accurate observations of a satellite as atmospheric resistance is braking its motion and bringing it down to the Earth should here be most informative. (It is not expected that these first bodies will be permanent companions of our planet; they may remain in orbit from a few hours to a few years, according to their distances from the Earth's surface). The satellite will be struck by the micrometeorites which abound in cosmic space; these will pit its surface and may alter its orbit slightly, thus giving an opportunity to estimate reliably the density of micrometeorites in outer space. The first satellites can carry very little instrumentation, so that we shall be largely or wholly dependent upon accurate position-measurements to glean information from them. We naturally hope for bigger, better and fancier satellites in the more distant future; and perhaps the chief results from their study will be ones which no one can even guess at now.

Each satellite will be launched into its orbit by being ejected from the third stage of a multiple stage rocket. The three stages are necessary to achieve the requisite orbital velocity of approximately 18,000 miles per hour. The rocket will be fired in a generally south-easterly direction over the West Indies from Patrick Air Force Base in Florida. The first and second stages will separate and fall into the ocean after burning out. It is desired to achieve an orbit with a perigee about 200 miles above the Earth's surface, an apogee about 800 miles above the Earth's surface, and an inclination to our equator of 30 to 40 degrees. It is perhaps needless to say that all these plans are subject to change, and it is perhaps even more needless to say that all rocket components must function perfectly if the actual orbit is to resemble the intended one. The period of revolution around the Earth depends only on the mean altitude above the Earth's surface and will be about 100 minutes for a mean altitude of 500 miles. If the inclination to the equator is 40 degrees, then the satellite will never pass overhead at latitudes of more than 40 degrees. Observers in the British Isles would thus see the satellite in the southern sky when it is near its maximum distance north of the equator. (Some allowance must of course be made for the satellite's altitude at the time.)

As mentioned above, accurate position measurements of the first satellites are needed. Radio and optical systems are being developed for this purpose, and well-equipped observing-stations are being set up at a number of suitable sites widely scattered over the Earth. Most amateur astronomers, however, will be personally more interested in what it may be possible to *see* of the satellite. This object will move in our sky from west to east, unlike all natural celestial bodies, at a maximum rate of more than a degree per second when in the zenith for an observer 200 miles beneath the satellite. If the distance above the Earth's surface is increased to 800 miles, this zenith angular velocity will be diminished to about one-third of a degree per second. The satellite is thus a real speeder, and the chances of catching it in the limited field of view of an ordinary astronomical telescope are almost nil. Thus wide-field binoculars or monoculars are indicated for our satellite-search. Next, we must realize that the satellite is going to spend some portion of each revolution in the Earth's shadow, in which it will naturally be invisible. Therefore, when it is at its perigee distance of only 200 miles from the Earth's surface, we must look for it either late in the evening twilight or early in the morning twilight (an hour a bit awkward for most of us) since the object will very seldom be seen against a fully dark sky. At greater distances from the Earth the satellite will spend a longer period of time against a dark sky, but it will naturally be dimmer at the larger distance. The observed stellar magnitude will range from six to nine. Thus the object will at best be barely visible to the unaided eye.

It should be evident by now that searching for the satellite is a project for a *team of observers*, not for the

individual observer. It would require accurate foreknowledge of the object's orbit to allow any individual to direct a pair of binoculars to the proper place in the sky at the correct time. A team of observers, however, can set up an "optical fence" in the sky over which the body must pass. (We are here assuming that an approximate orbit is known. Yet even in the most general case, in which the orbit is not known at all, a sufficiently large number of teams of observers watching in proper directions at the proper times can set up "optical fences" over which the body must cross; and in this fashion the wandering satellite can eventually be spotted.) The "optical fence" might be made to coincide with part of the observing team's celestial meridian, for example, and such would be the most natural choice. Let us suppose that at a given station the satellite is expected to pass through the zenith at a certain time in the evening twilight. If we have for each observer a pair of binoculars with a field 8 degrees across, then with ten observers we can cover an arc of the celestial meridian 80 degrees long, centred at the zenith and extending down to altitude 50 degrees both north and south. In practice, we should want to permit some overlapping of the binocular fields and should thus need a few more observers to cover 80 degrees. Obviously, the binoculars must be accurately directed to known positions along the meridian and must hence be on mounts. Perhaps a few astronomy clubs with numerous enthusiastic members can even set up a second "optical fence" just east or west of the meridian. Catching our speeding companion in space as it passes through both "optical fences" would provide an excellent check against confusing the satellite with meteors, illusions due to eyestrain during prolonged watches, and illuminated objects low in the Earth's atmosphere.

We shall pause now to say a word about the administrative organization of "Moonwatch", as the visual search for the artificial satellites has been called. The word "Seesaw" has also been proposed ("I see it, I saw it"); and one wit even suggested "Mouse Hunt". The responsibility for the satellite tracking programme has been assigned to the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts. The Director of the Observatory is Dr. Fred L. Whipple, and the Associate Director of the Satellite Tracking Programme is Dr. J. Allen Hynek. The Coordinator of Visual Observations in this project is Dr. Armand N. Spitz, the maker of the Spitz Planetaria. It is anticipated that many amateur observers outside of the United States will wish to participate in the visual programme. These persons should make their desires known to the Smithsonian Astrophysical Observatory *through their respective International Geophysical Year Committees*. Plans are to appoint an authorized co-ordinator of visual observers in each country. It will be an advantage to have as many countries as possible join the programme. For example, important stages in the final destruction of the satellite by atmospheric resistance might be unobservable from any one country. Persons interested in this programme should certainly place themselves on the mailing list of the Smithsonian Astrophysical Observatory's *Bulletin for Visual Observers of Satellites*. The writer will be glad to process inquiries at his address, 1203 N. Alameda Blvd., Las Cruces, New Mexico, U.S.A. Alternately, arrangements might be worked out for group-mailings of bulletins to specified persons or institutions in Great Britain and elsewhere.

Let us now return to the problem of observing the satellite. The desired data are the altitude and time of meridian passage, and naturally also whether south or north of the zenith. It is thought that the altitude should be given to within one degree or less and that the time should be given to within one second or less. Since the centre of the field of view of the mounted binoculars or monoculars will have to be known accurately, quick visual estimates may serve to supply useful altitudes; obviously, the angular diameter of the field of view must also be known. It will further be helpful to refer the motion of the satellite to the background stars and to note the direction of its path relative to their diurnal drifts. The observer must clearly be prepared in advance to do all these things; the satellite will not wait, and it will always be well within the field of view before it is recognized as an unusual object. *Only its motion* will distinguish it from stars. Securing exact records of time will almost certainly require some radio receiving equipment at each station, with stop watches perhaps serving as auxiliaries. It will help considerably to make the celestial meridian physically visible to all the observers, and one proposal is to mount a cross-bar on a pole so that it will be seen as a dark meridian in the field of each instrument.

Already observing-stations are being organized in the United States. The ideal instrument for the project should have an objective diameter of about 2 inches, a power of about 7×, and a field of view of about 10 degrees. Some amateurs may even design and make their own optics to these approximate standards. It should be self-evident that each member of the team of observers must be very reliable. He who frequently deserts his post for the cinema or the dance-hall will be worse than useless. The programme will probably require from each participating observer about three evenings and three mornings a month, with each vigil lasting one to two hours. The visual observer must maintain the closest attentiveness throughout this period, and perhaps it will be found wise to relieve observers every 30 minutes or so. Under certain conditions the lights on aircraft at night will simulate the motion of the satellite; and here observers may have an opportunity for some valuable and instructive practice-sessions, perhaps even engaging the pilot of a small plane to fly a predetermined course.

The satellite programme provides the amateur observer with both an unique opportunity and a definite responsibility. If we fail to man our stations, if we make poor observations, and if we frequently report other objects to be the satellite, our professional friends are not likely

to ask us again to participate in one of their projects. But if we show ourselves to be trustworthy and accurate observers and if we help to supply useful data about the satellites, then we may hope to be invited to share in other major scientific programmes in the future. The door is open to us.

Glossary of some Terms used in Rocket Engineering

By D. HURDEN

CATALYST. A substance which greatly accelerates a chemical reaction without itself being changed. For instance in the manufacture of sulphuric acid, sulphur trioxide is formed from sulphur dioxide and oxygen in the presence of finely-divided platinum which acts as the catalyst. Similarly hydrogen peroxide can be decomposed into steam and oxygen by a number of substances.

CAVITATION. A phenomenon occurring in pumps and other hydraulic machinery when the fluid pressure falls locally to a certain critical value. Bubbles of vapour then form in the fluid and collapse again on reaching a region at a higher pressure. The formation of bubbles can limit the performance of a pump, and their collapse can be so violent as to cause mechanical damage.

CENTRIFUGAL PUMP. A machine for pumping liquids in which a rotor having a number of blades—similar to a paddle-wheel—rotates in a casing. Liquid flows into the pump at the centre of the rotor, flies outwards through the rotor, and is led out of the casing by means of a tangential outlet.

ESCAPE VELOCITY. The velocity to which a body, whether particle or spaceship, must be accelerated so that it will never return to its parent planet. A body leaving the surface of the Earth with a velocity of about 7 miles/sec. will never return unless acted upon by some other force; 7 miles/sec. is the "velocity of escape" from the Earth.

MACH NUMBER. The ratio of actual velocity of a body to the local velocity of sound. An aircraft travelling at 600 m.p.h. (880 ft./sec.) at 60,000 ft. (where the velocity of sound is 970 ft./sec.) is flying at Mach No. of $880/970 = 0{\cdot}91$. In a rocket exhaust where the gases are moving at 6,000 ft./sec., however, the velocity of sound is 2,000 ft./sec., so the Mach No. is 3.

PROPELLANT. A collective term used to describe the substances which burn in a rocket motor. A propellant can be either fuel or oxidizer, while the term "propellants" is a short way of referring to fuel and oxidizer together.

PYROTECHNIC. A firework. A Fifth-of-November rocket or catherine wheel is a pyrotechnic, and modified forms of these have been used to ignite liquid propellant rockets.

REGENERATIVE COOLING. The method of cooling a rocket combustion chamber in which one of the propellants is made to flow through a jacket surrounding the chamber on its way to be burnt. Most of the heat picked up by the liquid from the wall of the combustion chamber is thus returned when the propellant is injected and is not lost.

SOUNDING ROCKET. A rocket-propelled vehicle which carries instruments to a great altitude. The readings of the instruments are transmitted by radio back to the ground from the rocket, which is therefore regarded as "sounding" conditions in the upper atmosphere.

SPECIFIC IMPULSE. The most commonly used criterion of the performance of a rocket engine. It represents the thrust produced by burning one pound of propellants per second in the rocket, and is therefore obtained by dividing the thrust in pounds by the weight flow of propellants in pounds per second. Inspection of these units will show why specific impulse is normally quoted in seconds.

SPECIFIC THRUST. The same as Specific Impulse.

STEP ROCKET. A rocket-propelled vehicle consisting of a number of sections, each with its own power plant. The whole vehicle takes off at first with one rocket engine firing, and having reached a certain velocity the lowest section is jettisoned, the next rocket is started, and the remainder of the vehicle is accelerated to a higher velocity. The process is repeated until only the last section is left. This form of construction is the lightest way of accelerating a payload to a very high velocity, since unwanted weight is thrown away as soon as it ceases to be useful.

TOTAL IMPULSE. The product obtained by multiplying the thrust of a rocket in pounds by the length of its run in seconds. For engines of variable thrust this quantity must be obtained by integration.

The Moon—Earth's Nearest Neighbour

By E. A. WHITAKER, F.R.A.S., Director of the Lunar Section of the British Astronomical Association

The lunar world; its nature, its features, and the conditions which we must expect to meet on its surface.

It is a curious fact that today, the amount of time and energy spent by professional astronomers in the study of the various celestial bodies is roughly inversely proportional to the nearness of these bodies to the Earth. Thus, the great bulk of astronomical research at present is directed towards such matters as the physical constitution of stars, Galactic structure, and the nature of the Universe, while our closest neighbours, the other members of the Solar System, are largely neglected in comparison. Earth's nearest neighbour, the Moon, is no exception to this rule, and the rate of increase of our understanding and knowledge of this body bears little relation to its proximity. A good deal of this knowledge has been gained through the efforts and observations of amateur astronomers, who find the Moon an ideal object for their attentions; but as the average amateur's equipment consists of nothing more than a plain telescope, it is not surprising that the bulk of this knowledge is of the topographical details of the surface of our satellite.

The ancients spent a great deal of time in watching the celestial bodies; they were well aware of the unchanging patterns of the stars, of the movements of the Sun, Moon and planets against this background, of the periodicity of such events as eclipses, etc. It would seem, however, that their celestial scrutinies did not extend to a close study of the appearance of the Moon at different phases, or of the appearance of the same phase at different lunations, or they would have discovered that the Moon does not always present exactly the same face towards us, and they might have suspected that the Moon's surface is not absolutely smooth. (One "lunation" is reckoned from one New Moon to the next.)

Although the ancient Greeks knew that the Moon was a solid, opaque sphere, possessing no light of its own and being visible merely because of its illumination by the Sun, these ideas were not universally accepted until comparatively recently. The dark markings on the face of the Moon exercised the imaginations of generation upon generation of our forbears; they were variously considered to be seas, forests, etc., and quite a popular conception was that the Moon was a mirror, and that the dark markings merely reflections of the terrestrial oceans! The faint illumination of the entire Moon at the times of the narrow crescent or decrescent phases was explained by assuming the body of the Moon to be translucent.

Such fantastic beliefs were held until the invention of the telescope in the first decade of the seventeenth century; even then there were some who refused to abandon the old ideas! Galileo, of course, was the first to examine the Moon in detail through a telescope, and to draw certain conclusions from what he saw. He correctly asserted that the Moon was an opaque sphere, and that, far from being smooth, its surface was extremely irregular and rugged. He recognized that the greater part of this ruggedness was caused by numerous circular depressions, each being girt with a rampart of mountains. He also recognized that in many cases no connection existed between the surface markings and topographical details, although, of course, he was fully aware of the comparative smoothness of the larger dark areas. He also made a very rough estimate of the height of a lunar mountain by noting the distance (as a fraction of the lunar diameter) beyond the terminator,* at a quarter phase, of a lunar peak just catching the Sun's rays on its summit. His estimate of five miles is certainly too large, but is at least of the right order of magnitude. He also correctly explained the phenomenon of "the old Moon in the new Moon's arms" as being due to sunlight reflected from the Earth, thus agreeing with Leonardo da Vinci.

Another discovery of Galileo's, made somewhat later, was the fact that the Moon did not present exactly the same face towards the Earth all the time, but that it appeared to rock backwards and forwards slightly. This motion can be readily detected without any optical aid whatever by noting the positions of the dark markings relative to the edge of the disk at fortnightly intervals, or by doing the same at full Moon for several successive lunations. Similarly, the boundary between the illuminated and dark portions of the lunar disk can frequently be seen to be irregular, being indented here and there by light or dark excrescences.

Progress in lunar studies was made but slowly after the excellent lead given by Galileo, and was mostly confined to the drawing of maps of the lunar disk, depicting both the surface markings and topographical details. A Belgian engineer-mathematician-astronomer by the name of Michel Van Langren, who invented a forerunner of the machine-gun, was the first to draw a map of this nature. His original intention was to employ the map in conjunction with tables giving times of sunrise and sunset on the various lunar formations, in order to determine geographic longitudes, a matter of some difficulty in those days. A contemporary German

* The "terminator" is the boundary between the sunlit and night portions of the Moon. To an observer standing on the lunar surface at the terminator, therefore, the Sun would be just rising or just setting.

FIG 1. Riccioli's Lunar Map, 1651

astronomer, Johann Hevel, published a complete folio volume (*Selenographia*, 1647) on the results of his lunar observations; he discovered that the Moon also possessed a nodding motion as well as the sideways rocking motion, and that the terminator, if it happened to pass through two given formations simultaneously during one lunation, would not quite do so during succeeding lunations. Van Langren realized the need for some method of identifying the various features marked on his map, and achieved this by attaching to each the name of some well-known person, such as members of royalty, famous philosophers, ecclesiastical dignitaries, etc. Hevel rejected this scheme, and used terrestrial analogies instead. However, in 1651, an Italian Jesuit astronomer, Giovanni Riccioli, renamed the formations once again, using almost exclusively the names of ancient and contemporary astronomers. This system has prevailed to this day, and the great majority of Riccioli's names still apply to the formations originally so named by him.

FIG. 3

FIG. 2. The Mare Serenitatis area of the Moon

The first to attempt to account for the mode of formation of the various lunar features appears to have been Robert Hooke, better known for his researches on elasticity, for the invention of the hairspring for watches, and for devising the well-known universal joint bearing his name. He likened the lunar surface to the surface of boiling alabaster after it had been removed from the fire; the last bubbles to burst left behind circular indentations with raised rims, very similar in appearance to a great many of the lunar formations. He also made experiments by dropping bullets into soft pipeclay, noting that again similar formations resulted; but he rejected this idea on the grounds that the lunar surface was not soft and plastic, and that it was not bombarded by missiles. The fact that the floor of one of the lunar formations which he happened to observe was darker than the surrounding mountains, led Hooke to think that "the Vale may have vegetables analogus (*sic*) to our grass, shrubs, and trees".

The following hundred years saw little progress in lunar studies; only two maps worthy of the name were published, and a few papers on such subjects as the evidence for a lunar atmosphere, the temperature of the Moon, the evidence for the existence of active volcanoes, etc., made their appearance.

The first comprehensive systematic examination of the lunar surface was undertaken by a German amateur, Johann Schröter. Equipped with reflecting telescopes made by Herschel and Schräder, he observed the Moon on every available occasion over a period of many years. He sketched various areas of the lunar surface in greater detail than had ever been accomplished before; he made numerous measurements of the heights of lunar mountains and the depths of lunar craters; he attempted to detect changes on the surface by comparing his drawings with the earlier maps, or with his own earlier drawings; and he made observations with a view to detecting the presence or otherwise of a lunar atmosphere. Schröter concluded that changes did occur on the lunar surface, and that the Moon possessed an atmosphere; we know today that he was wrong in both these conclusions, and that they were arrived at through a failure to recognize the effects of deficiencies in his equipment, and of certain other factors.

Schröter's work gave an impetus to lunar studies, and the advent of the nineteenth century saw a considerable increase in the output of papers concerning the lunar surface, of theories to account for the surface configurations, of evidence for changes, etc., and several lunar maps made their appearance, each containing more detail than its predecessors. The application of photography to the Moon proved to be very successful, and the study of such photographs is an essential supplement to visual observations. Although a complete collection of all published work concerning the Moon (excluding material dealing with the Moon's motions) would occupy a large bookcase, a great deal of this material is little more than speculation, or is based on extremely slender evidence, and it is found that the total quantity of concrete facts is surprisingly small. Let us see just what these facts are.

FIG. 4. The Full Moon

The Moon is, apart from the irregularities of its surface, an almost exactly spherical body, 2160 miles in diameter. From the fact that it is only about 1/81 as massive as the Earth, it can easily be calculated that its mean density is slightly less than $3\frac{1}{2}$ times that of water, and that its gravitational pull at its surface is only $\frac{1}{6}$ of that at the Earth's surface. Telescopic observation reveals at once that the Moon does not possess an atmosphere that is in any way comparable with that of the Earth. Thus, when the Moon passes in front of a star or a planet, the light of the object is not dimmed in the slightest degree as the body of the Moon approaches, neither does the object suffer any displacement from its normal position. Another frequently quoted argument against the existence of a lunar atmosphere is the absence of twilight effects; it is easy to show, however, that this is a far less sensitive test than those just quoted. None of these observations preclude the possibility of an extremely tenuous atmosphere, or of temporary local exhalations . . . but we are beginning to speculate.

It can also be shown that there is no water in any form on the lunar surface; however, theories have been propounded to account for the lunar features which require the presence of ice, or the presence in the past of large quantities of water. It is quite evident that no pools of water exist in the Moon's equatorial regions, otherwise they would have been detected from the specular reflection of the Sun's rays that one would expect from their surfaces. In any case, we know that a perfect, or almost perfect vacuum exists at the Moon's surface; under these conditions, water would evaporate quite rapidly, of

course, so that we may safely assume that no water exists there. If ice were present, it would again betray its presence by specular reflection, since ice flows slowly under the pressure of its own weight and would, in time, adjust itself to its own level in a similar way to water. In any case, ice evaporates slowly, and the absence of an atmosphere would allow the water vapour to escape into space.

The temperature of the Moon's surface has been ascertained on several occasions by measuring the quantity of heat received from the Moon. It is found that at places where the Sun's rays fall vertically upon the surface, the temperature surpasses that of boiling water, while on the unilluminated side of the Moon, the temperature drops to $-150°$ C. Similar observations made during lunar eclipses show that the surface

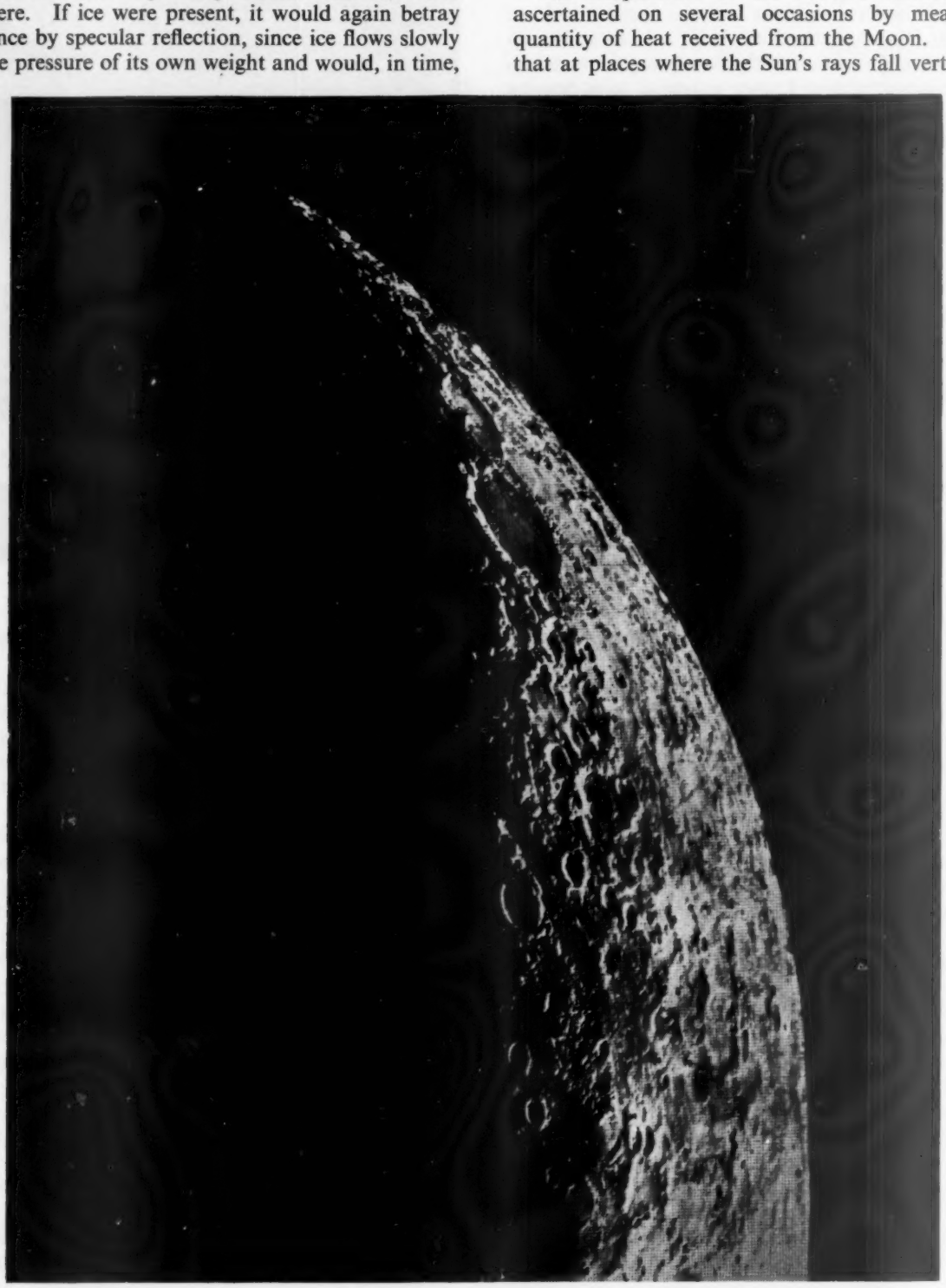


FIG. 5. The crescent Moon—shortly before New. The large crater on the terminator, near the top of the picture, is Schickard

temperature drops extremely rapidly as the Earth's shadow advances across the disk; this proves that the material of the lunar surface is an extremely poor conductor of heat, and has a low specific heat. The only substances having such properties are loosely packed dust, ash, coarse powder, etc. We may therefore conclude that the flatter portions of the lunar surface are covered with a layer of some such material.

reflective than chalk, and probably simulate very light sand in this property; the darkest portions probably reflect about as much light as very dark slate or black volcanic lava. Experiments have also been made by examining the degree of polarization of the sunlight reflected from the Moon's surface, with a view to attempting to determine the chemical nature of the surface material. Results are inconclusive, but indicate a

FIG. 6. Maurolycus and environs

Measurements of the quantity of light reflected from the Moon at different phases show that its surface is very rugged, i.e., rugged to a much finer degree than can be observed telescopically. Further experiments show that the Moon reflects only about 7 per cent. of the sunlight incident upon it; this is similar to the reflectivity of rather dark rocks such as slate, basalt, dark sandstone, etc. The brightest portions of the lunar surface are less similar behaviour to olivine, a major component of the Earth's crust.

So far, no mention has been made of the Moon's surface markings and topographical details. If we view the full Moon through binoculars or a small telescope, we see at once that the material constituting the surface rocks and dust is far from homogeneous, i.e., its reflectivity varies widely from area to area, as already noted.

FIG. 7. The giant crater Clavius. 200 in. photograph. Reproduced by courtesy of Mt. Wilson and Palomar Observatories

FIG. 8. The lunar crater Copernicus and area. 200 in. photo. Reproduced by courtesy of Mt. Wilson and Palomar Observatories

Although there is an obvious distinction between the brighter ("continental") areas, and the darker "seas" each is seen to be mottled to a considerable degree, and in some locations, brighter and darker areas merge imperceptibly into each other. Another obvious feature are the systems of bright "rays", emanating from certain centres situated in both the seas and continental areas. A closer scrutiny of the surface reveals that it is not entirely of a neutral tint, but that certain areas display a colouration. The bright continental areas do not appear to display any such tinting, but the coloured areas in some of the seas are readily detectable. Thus Mare Serenitatis, apart from its greyish border, has a distinct buff or greenish-yellow tint, which contrasts strongly with the almost bluish-grey of the neighbouring Mare Tranquillitatis; a diamond-shaped area east of the formation Aristarchus has a distinct yellowish tinge, and so on. These results are fully borne out by photographs which have been taken in violet and red light; areas displaying buff or yellowish tints appear light in the red photos, but quite dark in the violet ones.

Both these differences of colouration and of reflectivity clearly represent inherent variations in the chemical and/or physical nature of the materials of which the lunar surface is composed; but just what these materials are we cannot say at present. The true nature of the bright "rays" which surround many of the lunar features is another enigma which has still to be solved; observation shows that they must be very superficial features, since they are neither raised above nor depressed below the general surface.

The Moon's topographical details have been observed far more thoroughly than any of the foregoing characteristics, and it is fair to say that the visible hemisphere of the Moon contains very much less unexplored territory than does the Earth. The positions of well over 2000 formations are known to an accuracy of a fraction of a mile, and the heights of several hundred mountain peaks and the depths of a great number of craters have been measured. More recently, attempts have been made to ascertain the true figure of the Moon, i.e., to try to measure the departure from a perfect sphere; results so far indicate that the figure is an ellipsoid with three unequal axes, but that, contrary to expectation, the major axis is not directed towards the Earth.

It is not proposed to describe here the various types of features that go to make up the lunar surface, since whole books have been written on this subject. However, several misconceptions have arisen concerning some of these features, and a few notes about these would not be out of place. These misconceptions can all be traced to a failure, on the part of observers, to appreciate the exaggerated effect of relief that is obtained when formations are illuminated by a very low Sun, i.e., when they are lying close to the terminator. Thus, at places on the lunar surface where the Sun has just fully risen, the lengths of shadows are over 100 times as great as the heights of the eminences which cast them; hills with very moderately sloped sides cast long, tapering shadows, as also do the slight walls of many of the craterlets. This has given rise to the misconception of towering, pinnacle-like lunar peaks and steep-sided, volcano-like craters with yawning central openings. In fact, the great majority of slopes on the Moon do not exceed 30 degrees, and slopes in excess of 45 degrees are quite rare; this does not rule out the possibility of greater angles of slope in the general ruggedness of the surface which is beyond the resolution of our best telescopes. The lunar craters are also comparatively shallow formations, being similar to the Arizona meteor crater in general contour. The larger mountain-walled plains and ring-plains are even shallower in cross-section; indeed, in some cases an observer standing at the centre of one of these formations would be unable to see the encircling mountains, since they would be below his horizon!

Another erroneous conception is that of long, winding, almost bottomless chasms, with widths of the order of a mile or more, stretching across the lunar landscape. Under very low angles of illumination, the lunar clefts certainly give the impression of great depth, but under higher lighting they can be seen to be similar in cross-section to the neighbouring craters. The surface of the Moon also displays several great "faults", i.e., lines of cleavage separating areas at different levels; these have been depicted as towering, vertical cliffs in certain popular literature, but a little careful observation will suffice to show that the angles of slope are of the order of 45 degrees.

So much for the actual known facts about the Moon; however, we may infer a little more about the conditions existing at the Moon's surface. Thus, we know that the Earth's atmosphere effectively filters out the ultra-violet light from the Sun, as well as the showers of electrons or other corpuscles emitted at certain times. Similarly, this atmosphere fends off the numerous tiny meteors which rain down ceaselessly; but the lunar surface, having no protective atmospheric mantle, would receive these radiations and bodies in undiminished intensity. Another consequence of the absence of air would be a completely black sky even when the Sun was shining in it.

Such, very briefly, is our present knowledge of the Moon; a concerted research by astronomers could undoubtedly increase this knowledge a good deal. But the Scientific Lunar Expedition of the future will bring back a wealth of information and, quite certainly, a whole batch of new enigmas to be solved.

Goddard—Father of Modern Rocketry

By G. V. E. THOMPSON, B.SC., A.R.C.S., F.R.I.C., L.I.M.

The life and work of the great pioneer who fired the first of all liquid-fuel rockets.

This article is the second of a series dealing with the lives of the men and women who have made or are making notable contributions to astronautics; the first dealt with the Russian pioneer, Konstantin Eduardovich Tsiolkovskii. If, as we have seen, Tsiolkovskii can be considered the founder of the science of astronautics, then Professor Robert Hutchings Goddard well merits the title of "father of modern rocketry". He was certainly the greatest experimental pioneer in this subject —not a mere dabbling inventor, but one who understood the principles involved and was capable also of developing the necessary theories, as was to be expected from his successful academic career.

Born on October 5, 1882, in Worcester, Massachusetts, he went to school at Boston and then to Worcester Polytechnic Institute, obtaining his B.Sc. degree in 1908. He was an instructor in physics at the Institute until 1911, during which period he obtained his M.A. and Ph.D. After two years as a research fellow at Princeton University, he went to Clark University, where he was successively instructor, assistant professor, and professor of physics. This was a more-or-less conventional course to follow and was accompanied by the sort of research achievements that one might expect from a professor of physics—mainly in electricity and magnetism.

However, Goddard is not now remembered for his work on electricity. He had long been interested in rockets, this interest probably originating because of their potential use for high-altitude meteorological measurements—a use which is of great importance today and is one of the reasons for undertaking Project Vanguard. Even whilst an instructor at Worcester Polytechnic Institute, Goddard carried out rocket experiments in the basement, to the annoyance of the other occupants of the building. There does not seem to be any record of his having tried to continue his experiments when he went to Princeton, but whilst there he made some preliminary calculations which showed that a relatively small quantity of propellant would enable instruments to be carried to great heights.

On moving to Clark University in 1914, he recommenced his experiments, first using naval rockets but then developing other types himself. The work was financed out of his own pocket, and he soon found himself running out of money. In order that he might be able to continue, he prepared a report for submission to the Smithsonian Institution with a request for a grant of $5000. The Smithsonian is a remarkable American organization, established by Act of Congress in 1846 in accordance with the terms of the will of an Englishman, James Smithson, who bequeathed his property to the U.S.A. to found "an establishment for the increase and diffusion of knowledge among men". Its "members" comprise the U.S. President, Vice-President, members of the government and the Chief Justice, but it is administered by a group of prominent citizens and Members of Congress with the very un-republican title of "Regents". It is now a combination of national museum, zoo, art gallery and observatory. The report submitted by Goddard contained the theoretical work developed whilst he was at Princeton but also gave the data he had obtained subsequently in his experiments employing nitrocellulose smokeless powder as a propellant (including tests carried out in a vacuum, to simulate the conditions which would prevail at high altitudes). In a

Dr. Robert H. Goddard, rocket pioneer and inventor

third section were various calculations based on theory and experiment; they included the effect of using bundles of individual rockets, the recovery of rocket-borne instruments, and the determination of the minimum mass required to raise one pound to an "infinite" altitude. Goddard diffidently remarked that it was of interest to speculate upon the possibility of proving that great altitudes had been reached and said that the only reliable procedure would be to fire a rocket containing flash powder at the dark surface of the Moon. He even made some tests to find out how much powder was needed to make a flash visible at a distance of $2\frac{1}{4}$ miles, and from this worked out that a rocket weighing about $3\frac{1}{4}$ tons would be required to carry sufficient flash powder to make a visible flash on the Moon. He went on to make the further rather vague statement (Goddard's italics):

> "This plan of sending a mass of flash powder to the surface of the Moon, although a matter of much general interest, is not of obvious scientific importance. There are, however, *developments of the general method under discussion, which involve a number of important features not herein mentioned*, which could lead to results of much scientific interest. These developments involve many experimental difficulties, to be sure; but they depend upon nothing that is really impossible."

The unspecified developments might be taken to include manned interplanetary travel. They might equally well refer to some kind of high-altitude meteorological experiments. Perhaps Goddard wanted the Smithsonian authorities to make the latter inference and regard his lunar calculations as a light-hearted academic exercise—or perhaps in thinking that I am being too hard on the Board of Regents. They might well have been more far-sighted than some of today's leaders of science. At any rate Goddard was given his $5000 (and further sums followed in due course) as a grant towards the development of a reloading or multiple-charge rocket. He began experiments at Worcester, but with the entry of the U.S.A. into World War I, he volunteered his services and was asked to develop military rockets. This work was done at Mount Wilson observatory, and various improved projectiles were devised. He did actually develop his reloading rocket in which solid fuel cartridges were fed into a combustion chamber in a manner similar to that used in machine guns. His weapons were successfully demonstrated at the Aberdeen Proving Ground on November 10, 1918, but the war ended the following day.

Although Goddard's missiles were not destined to win the war, he soon attained world-wide fame. In 1919, the Smithsonian Institution published his 1916 report (with a few additional notes) under the title "A Method of Reaching Extreme Altitudes", and this was released early in January, 1920. The idea of a Moon rocket captured the imagination of both press and public, and everyone became interested in what he was doing. Unfortunately Goddard chose to be very secretive, and when no information was forthcoming, people began to invent it. Statements were made that he had fired rocket torpedoes to heights of 100 miles and ranges of 300 miles. These were completely without truth.

But Goddard was carrying out some important research. As early as 1914 he had taken out a patent specification for a liquid propellant rocket. This type has many advantages over the conventional solid propellant rocket—the energy per unit mass of propellant is greater, it is possible to exercise more control over the operation of the rocket (there is even the possibility of stopping and starting it at will), etc. The large rockets and missiles of today employ liquid propellants. But thirty-five years ago there were many problems to be solved, and so Goddard experimented with liquid oxygen and various hydrocarbon fuels. The experiments consisted of simple static tests, the rocket motor or engine being held by springs in a frame; when firing occurred, it was seen that a thrust was developed. On March 26, 1926, the first flight of a liquid oxygen/petrol rocket took place at Auburn, Mass. It was a spidery-looking device, the combustion chamber being situated well ahead of the propellant tanks and connected to them merely by pipes. It was ignited by applying an ordinary blowtorch to the motor. However, the flight was apparently successful, although Goddard did not disclose this to the world until ten years later.

These experiments were carried out in Goddard's spare time, with the aid of grants first from Clark University (in 1920–22), then from the Smithsonian Institution (1922–30). In the later tests the combustion chamber was placed at the tail of the rocket, now its normal position. In 1929–30, the work was transferred to a War Department site at Fort Devens, but conditions in winter were still a hindrance. Then the celebrated aviator, Col. Charles Lindbergh, took an interest in the research and told Daniel Guggenheim about the work. Guggenheim made Goddard a grant, which (together with one from the Carnegie Institution) was sufficient for the research to be moved to Roswell, New Mexico, where the climate was more suitable; Goddard obtained leave of absence from Clark University.

Apart from an interruption from May, 1932 to October, 1934 (due to the economic depression) work proceeded satisfactorily at Roswell for some years. A gyroscope stabilizing system was developed and ascents of up to 7500 feet were made. A report on the work entitled "Liquid-Propellant Rocket Development" was eventually published by the Smithsonian Institution on March 16, 1936; it was illustrated with photographs taken by Goddard's wife, Esther Christine Kisk, whom he had married in 1924. Apart from many patents, the two Smithsonian reports constitute Goddard's only published works on rockets, yet his work continued after 1936. During World War II, he carried out further work for the U.S. Navy in the field of liquid propellant rockets and assisted take-off units for aeroplanes.

When the war ended he planned to return to New Mexico and high-altitude rockets, but this was not to be.

On August 10, 1945, he died after a throat operation. This was a few months after he had been elected to the Board of Directors of the American Rocket Society, and we can only echo the closing words of their tribute to him: "The life-work of Goddard, both as a scientist and a man, will always remain a brilliant inspiration to those who are privileged to carry on his endeavours, and to every other bold explorer on the new frontiers of science. In time to come, his name will be set among the foremost of American technical pioneers."

The Atmosphere of Mars

The high-level "violet layer" in the Martian atmosphere is of the same nature as the low-level "yellow clouds", in the opinion of Dr. R. M. Goody, who lectured to the British Interplanetary Society on "The Atmosphere of Mars" on November 3, 1956. The violet layer (so named because it appears bright in ultra-violet light photographs) clears away at times, so it cannot be due to a gas, because gases would take hundreds of years to separate out from each other. Moreover, its reflectivity is only 5 per cent., so it must be made of something which absorbs a large proportion of the Sun's radiation. Both these arguments, he said, point to solid particles suspended in the air as the cause of this layer.

Solid particles raised from the surface of the Martian deserts are assumed by Dr. Goody to be responsible also for the yellow clouds seen at times; yet their limited size and duration was something that he thought needed explaining, because the dust raised from the Earth's surface forms a permanent layer one or two kilometres thick.

Quite different are the white clouds, which he believed to be made of ice crystals of a great range of sizes, and certainly not of carbon dioxide. One variety of white clouds was seen covering each polar cap in winter; its ragged edge distinguished it from the actual cap, which has a sharp border. But here again is a mystery, for if the cloud is made of ice crystals, which are the only plausible explanation, it is nothing like as bright as it ought to be. Other white clouds are to be seen near the sunrise and sunset borders of the Martian disk, where temperatures are very much colder than at mid-day, so these clouds also are probably made of ice.

As to the atmosphere itself, Dr. Goody has reasons for doubting whether there is as much of it as the generally accepted figures indicate—surface density one-twelfth of that of the Earth, and pressure 85 millibars (Earth, around 1,000 millibars). The spectroscope shows it to possess fifteen times as much carbon dioxide as that of the Earth; this would account for 13 millibars, so that is the irreducible minimum of pressure for the Martian atmosphere, but it is practically certain to contain other gases too, particularly nitrogen, which is very difficult to detect by methods available to us.

The amount of precipitable water in the Martian atmosphere cannot be more than equivalent to a thickness of 0·001 cm., or there would be spectroscopic evidence for it; yet Dr. Goody, reasoning from the conditions under which ice clouds appear, makes it 0·003 cm. —another discrepancy waiting to be explained. The spectroscope likewise shows no evidence of oxygen in the atmosphere of Mars, so there cannot be more than 0·14 per cent. of the amount on the Earth. If there is any at all, a tiny proportion of it would be converted into ozone and absorb heat from the Sun.

Mars should have an ionosphere, in which gas molecules are split into atoms, and Dr. Goody estimated the height of its E layer as 210 km.

What about vegetation? At the outset of his lecture Dr. Goody said he was not very interested in answering questions about it, so his audience took the hint. But he went on to say that giving the known and certain facts about Mars would take up no more than the first minute of his lecture; all the rest would be speculation. However, Dr. Goody is a Reader in the Meteorological Department of the Imperial College of Science and a leading authority on the stratosphere, so his speculations will be well worth reading when the full text of his lecture appears in the periodical *Weather*.

At the end of the lecture Patrick Moore spoke a few words on the 1956 opposition of Mars, at the suggestion of the lecturer. It had been most disappointing for observers because of widespread 'haze' of unusual density in the planet's atmosphere, which obscured the details of the surface, and though the main dark areas could be distinguished, they had been unusually light in tone. It was now (November) improving at last, but Mars was receding fast after its unusually close approach in early September.

A. E. SLATER.

Oerlikon Rockets

By MAURICE F. ALLWARD

Some of the high-altitude rockets produced by the famous Oerlikon firm.

The high reputation that the Arms Division of the Swiss firm Oerlikon holds in the world of arms and ammunition is well known. Many readers will have been familiar with the famous Oerlikon 20 mm. cannon during the war, proof of the popularity of which is given by the fact that both sides used it—some 300,000 being made in the U.S.A., over 30,000 in Britain and several thousand in the Axis countries!

Not so well known is the firm's more recent work in the field of rockets, ranging from small air-to-air missiles to a big surface-to-air guided missile capable of bringing down the heaviest bomber.

For long specialists in airborne cannon, they developed none larger in bore than 30 mm. because larger calibres were considered less practical, and because the inevitably slower rate of fire made them less suitable for aircraft use. Instead, recent concentration has been on precision rockets which combine great destructive power with recoil-less functioning. This latter point, an inherent feature of all rocket missiles, is of particular importance for aircraft installations where the powerful recoil of conventional guns severely slows down the aircraft concerned.

In production is a powder rocket with a body diameter of 3·15 in., a length of 24 in. and a weight of 22 lb. At first glance this appears a simple enough missile, but the internal structure is extremely complicated. The fuse, for example, is a precision mechanism, comprising a watch-like movement. This is operated by the acceleration of the rocket, and primes the missile before it has travelled about 100 yards. The propulsive element comprises eight ducts machined to very close limits and protected against moisture by plastic skins, the powder content of each being weighed very accurately to ensure reliability. Between the warhead and the propulsive charge is a compartment containing the electric ignition mechanism.

Several versions of this rocket are in production. One contains an explosive warhead of 2·2 lb. with a contact-detonating fuse in the nose; one is armour-piercing with a percussion fuse in the base of the hollow explosive charge. For practice there is one with a dummy warhead or marking charge.

All these missiles may be fired either from aircraft, or from the ground by anti-aircraft units. Such versatility is of great importance from the point of view of storage and supply.

Other rockets include an air-to-air missile 2 in. in diameter, with folding fins. Carried in special canisters under the fuselage or on the wing tips, these are electrically ignited in pairs, and can be fired singly or automatically at given intervals.

Under active development is a high-explosive rocket with a proximity fuse. The warhead of this missile contains a real miniature power-plant with a gas turbine driven by the propulsive gases and a generator. The generator supplies power for a diminutive radar instrument which automatically measures the distance from the target and ignites the warhead at the proper moment.

Of most interest, however, is undoubtedly the big Oerlikon Type 54 guided missile. Intended for anti-aircraft duties, this is fired from the ground and is one of the few—if not the only—such missiles upon which detailed information has been released for publication.

It is a slim, finely streamlined projectile with a length of just under 20 ft., a maximum diameter of 16 in. and a weight of 770 lb. Four wings provide the lift necessary for controlled flight and four small fins at the rear are used for steering after burn-out. During the powered part of the flight steering is effected by deflection of the entire thrust chamber, with assistance from the four tail fins which are moved simultaneously. After burn-out, when steering is completely dependent on the tail fins, the angular movement of these is automatically increased.

The rocket motor runs on white fuming nitric acid and kerosene, these being forced into the combustion chamber by compressed nitrogen. The motor produces a thrust of 2205 lb. and burns for 30 seconds, by which time a height of 30,000 ft. has been reached. After this point the missile can be guided up to a height of about 60,000 ft.

The missile is controlled by what is known as the Beam Rider system. Under this system the missile is guided throughout the duration of its flight by a radar beaming device on the ground which locates the target and locks on to it. The missile is fitted with a rearward-looking receiver which, together with the control system, ensures that the missile continually searches for the centre of the beam. As the beam is locked on to the target the missile will be guided to it even though evasive manœuvres are carried out.

This system was adopted, so Oerlikon explain, because of its relative simplicity. Without any additional ground equipment the system allows several missiles to be guided on the same target, or on to a zone of targets. One of the most difficult problems in the launching of a guided missile, that of aim-off, is entirely eliminated, as the rocket flies continuously within the guiding beam, always endeavouring to intercept its target.

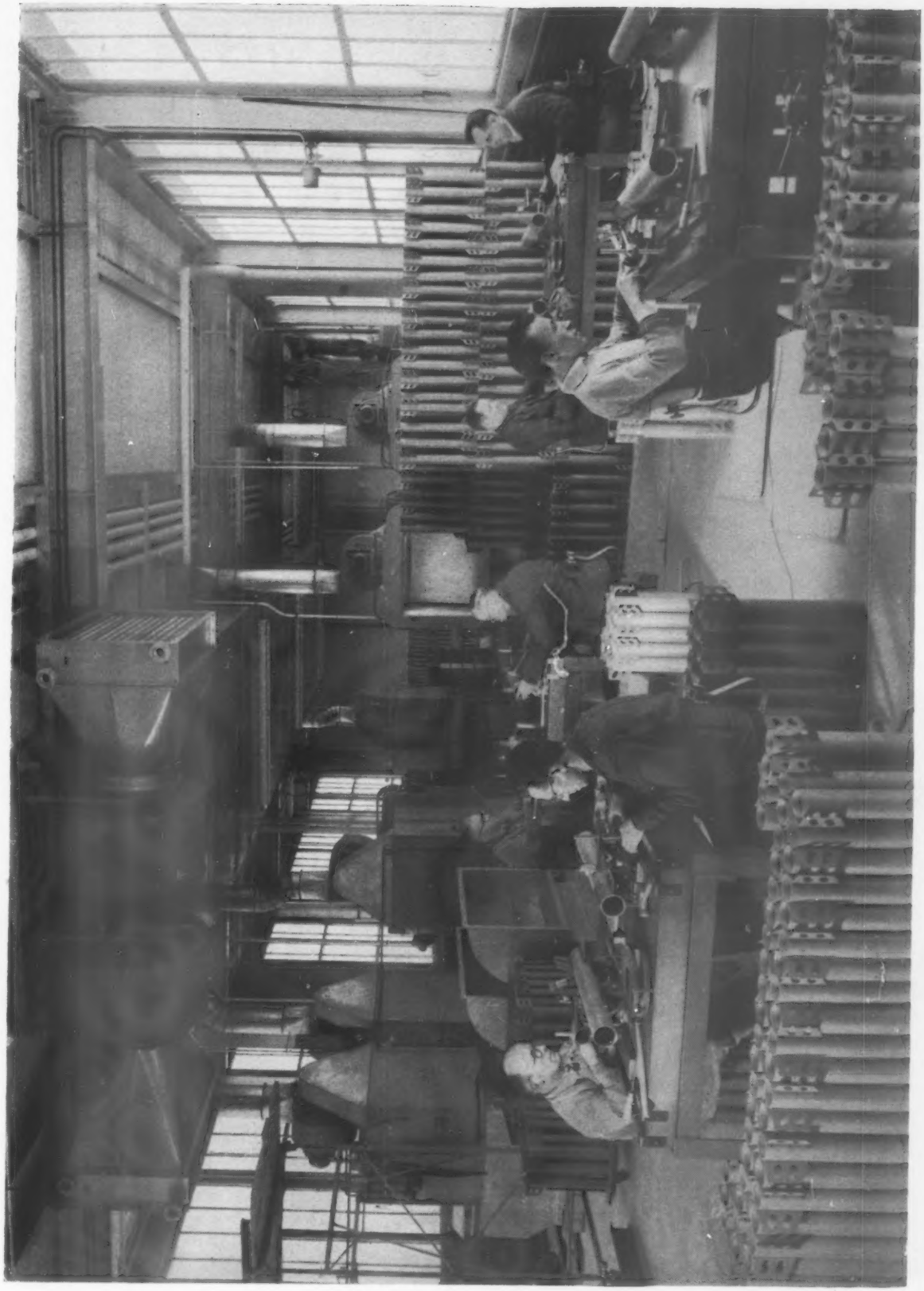


FIG. 1. Oerlikon 3·15 in. powder rockets in production

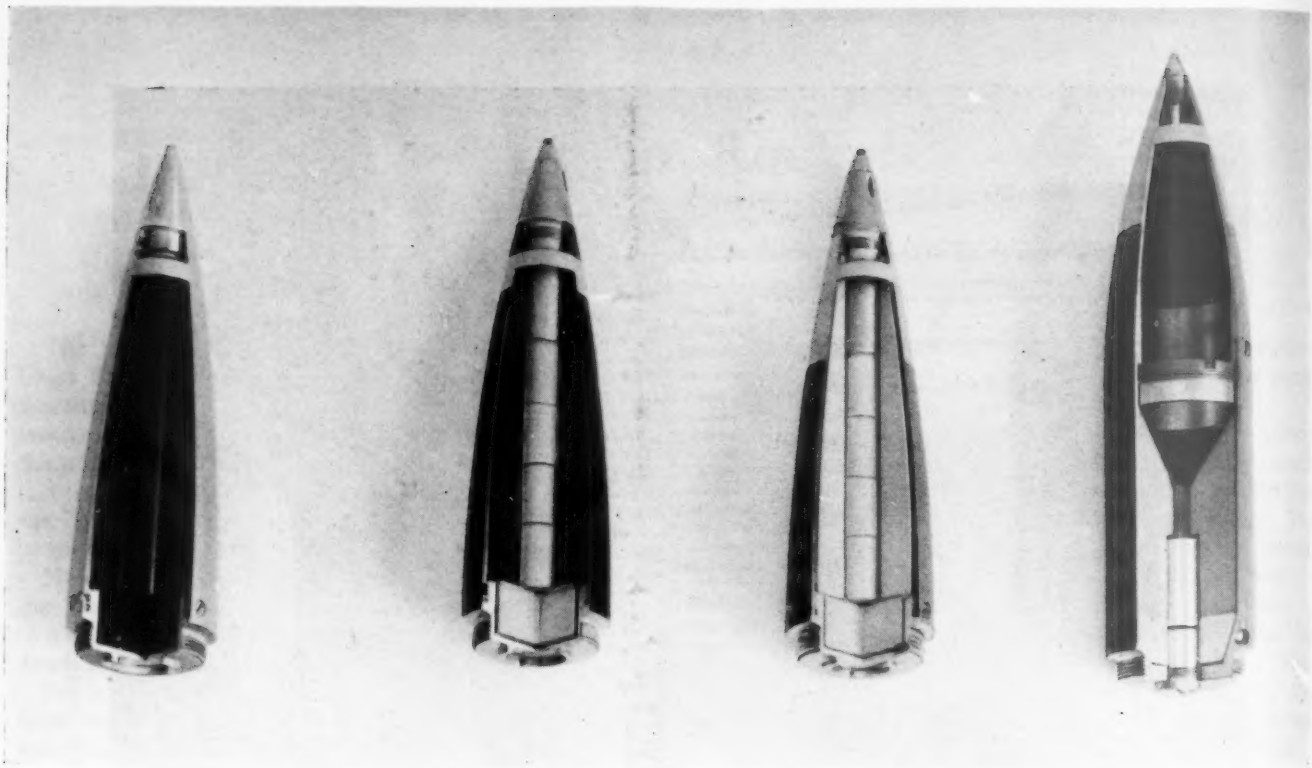


FIG. 2. War heads for the OERLIKON 3·15 in. powder rockets:
(1) Practice shell (inert).
(2) Practice shell with marking charge.
(3) Explosive shell (2 lbs. of explosive charge).
(4) Armour-piercing shell with shaped charge.

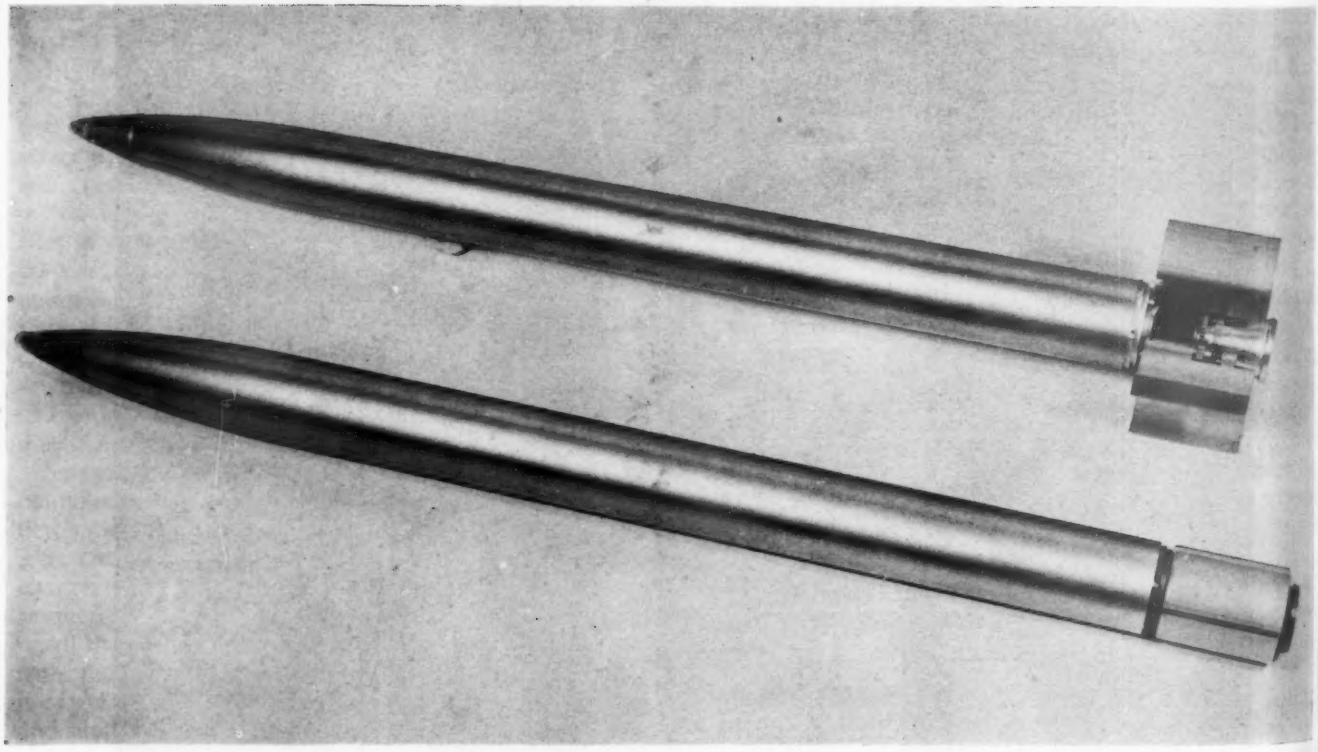
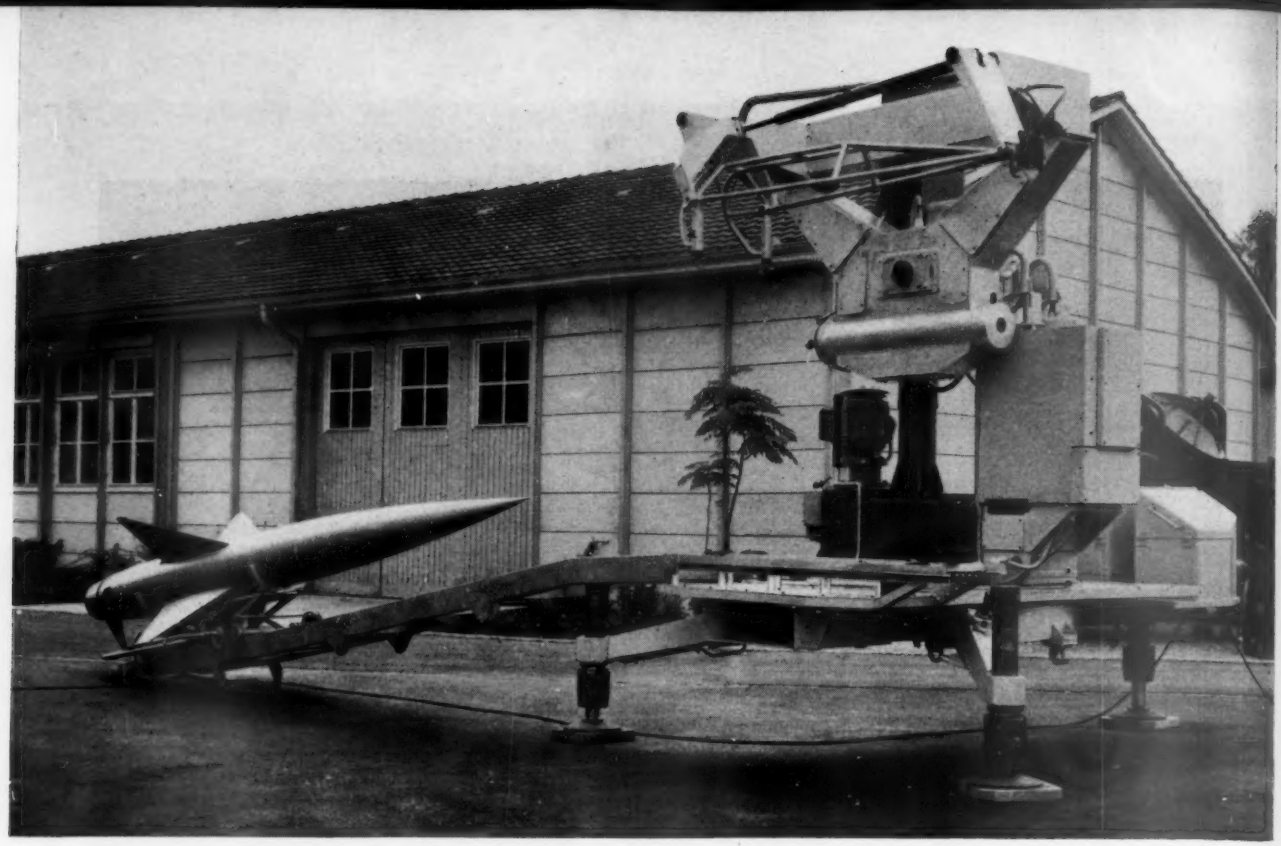
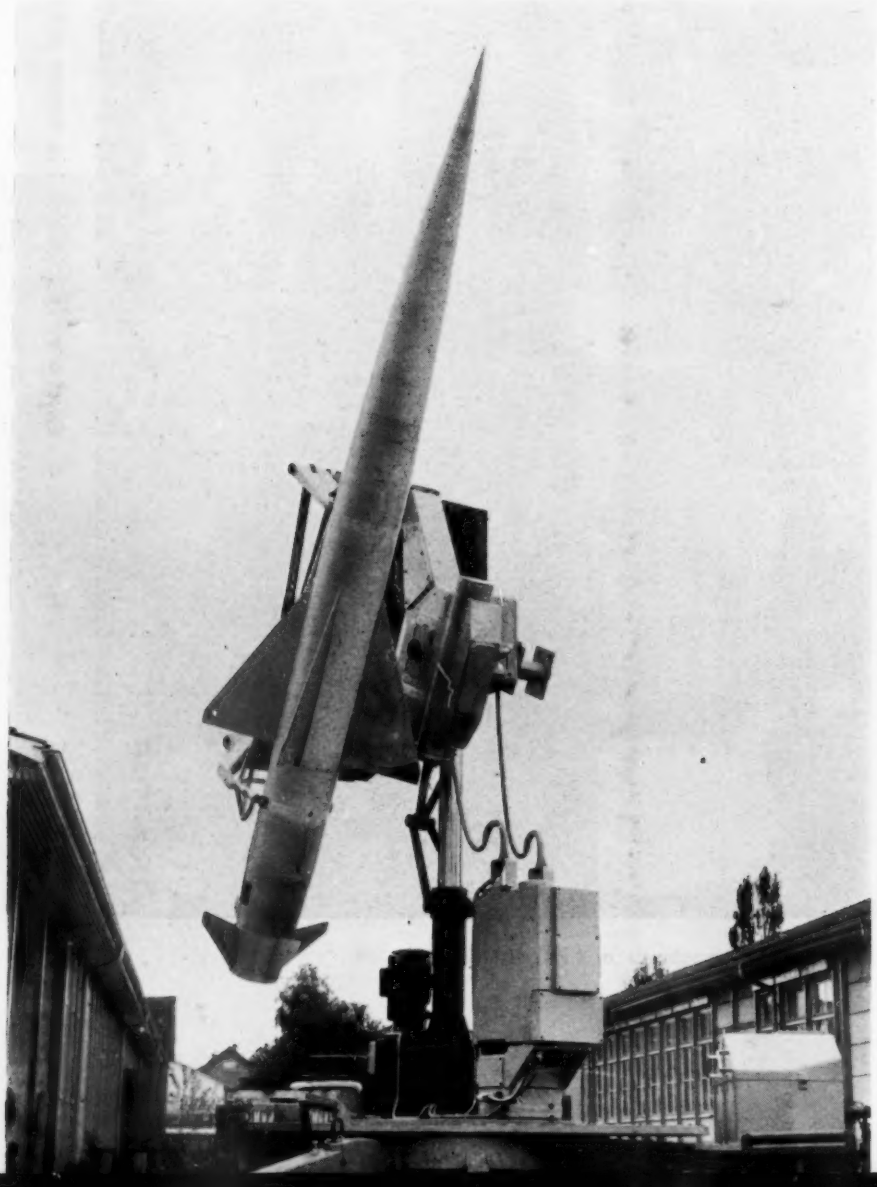


FIG. 3. OERLIKON 2 in. powder rockets with folding fins

FIG. 4. Effect of an OERLIKON 2 in. powder rocket on an all-metal aircraft wing



5(*a*)



5(*b*)

OERLIKON TYPE 54 GUIDED MISSILE

FIG. (5*a*). The missile is loaded on its launcher by hydraulic and pneumatic means

FIG. (5*b*). Electrical servo-mechanisms then elevate the missile into the launching position

FIG. 5(*c*). Fire! The missile speeds on its way. The launcher ensures it is launched into the guiding beam, the transmitter for which can be seen in the left foreground

FIG. 5(*d*). The missile streaks towards its target. With its guiding beam automatically locked on to the target and the missile following the centre of the beam, it travels unerringly towards its target

FIG. 5(*e*). An impression of a direct hit

5(c)

5(d)

5(e)

The beam transmitter sends out both a coarse and fine cone of signals with opening angles of 20° and 3° respectively. The coarse beam serves to "catch" the missile after the launching and to guide it towards the fine beam, which then directs the missile towards the target.

An extensive ground organization is required to operate the missile, a Firing Group comprising a central Command Post and three Firing Batteries. The Command Post is equipped with a putter-on radar, and each battery has its own radar tracker. This battery tracker is also provided with a telescope so that, under suitable conditions, a target can be tracked visually.

Where possible, early warning of the approach of enemy aircraft should be provided by a network of long-range radar stations at a distance of 200 miles. Where there is no early-warning network, the sky would be continuously scanned by the group putter-on radar equipment, giving an effective coverage of between 60 to 125 miles.

Once a target has been located by the group putter-on radar, it is transmitted to the individual batteries by the Group Command Post, where it is then tracked by means of the battery radar-tracker which, in turn, controls the beam transmitter and the missile launcher which holds the missile in the required position for firing.

Like all guided missiles the Type 54 is a very expensive piece of engineering, and every effort is made to save those fired during practice with as little damage as possible. Such missiles break into two portions at a given time after burn-out, each portion then being landed by parachutes which stream automatically at a relatively low altitude.

Should a missile get out of control for any reason, the motor can be cut by radio and emergency separation effected with immediate opening of the parachutes.

Although no information has been released concerning the efficiency of the weapon, there is little doubt that it maintains the high performance that has come to be accepted as standard for the conventional weapons of this outstanding armaments firm.

A Tribute to A. M. Low

By P. E. CLEATOR
Founder of the British Interplanetary Society

The death of A. M. Low at Chiswick on September 18, 1956, at the age of 68, has removed one of the pioneers of jet propulsion from the astronautical scene, and with his going, the British Interplanetary Society has lost one of its earliest members, and the second and last (at any rate to date) of its short line of Presidents.

It was during the war years of 1914–18, as an Experimental Officer operating under the aegis of what is now the R.A.F., that Low began an investigation of rocket control by radio, and thus initiated a programme of guided missile research. And that he also recognized the potentialities of the device as a means of locomotion in space, is shown by the fact that he was subsequently in touch with the *Verein für Raumschiffahrt e.V.* in Berlin.

Word of this pre-B.I.S. expression of interest in the interplanetary idea was conveyed to me by Willy Ley, soon after the inaugural events of 1933, and when invited to do so, Low promptly joined our small band of British would-be rocket experimenters. More, he rendered invaluable assistance to the Society in a number of ways —as a member of the editorial board of the now defunct *Armchair Science*, for example, he opened wide the columns of that once popular journal to a series of articles on space travel, so helping to promote an intelligent interest in our aims. Nor was it long before he became the acknowledged leader of B.I.S. members in the London area, and in June, 1936, it was officially announced that he had consented to act as Vice-President of the Society.

At that time, the presidential chair was occupied by me, but towards the end of the year, after prolonged disagreement with the local Council over questions of management and policy, I tendered my resignation. Control of the Society then passed unhindered from Liverpool to London, whereupon A. M. Low was elected President, and I undertook to serve under him as a Vice-President. This reversal of our former rôles continued, though no more than nominally during the dormancy of the war years, until 1945.

It would be disingenuous of me to profess to be unaware that for many years A. M. Low was regarded somewhat askance by the more orthodox members of his profession. For one thing, justly or otherwise, he earned for himself the reputation of a seeker after the limelight; for another, he was disdained as the possessor of an unrivalled capacity for commercialism (as evidenced, I dare say, by the 200-odd inventions which he had to his "discredit"); and for a third, he was looked down upon as one given to the reckless espousal of what (at the time) were almost universally dismissed as highly improbable and basically unsound ideas—e.g., that a practical system of television was on the way, that the release of nuclear energy was impending, and that in the days ahead, a passenger-carrying rocket would be despatched to the Moon.

No doubt Low, in common with most of us, had his foibles and his faults. But what his detractors really held against him, I suspect, was his disinclination to accept the complacency of their outlook as a substitute for the restless spirit of enquiry which was characteristic of his own. His attitude towards the idea of space travel, at all events, was typical. In the early days of the B.I.S., when a handful of us here joined in the task of proclaiming the unique merits of jet propulsion, not many were inclined to listen, and fewer still were disposed to help. A. M. Low did both.

The Seventh International Congress of Astronautics

By R. A. SMITH, Chairman of the British Interplanetary Society

A personal account of the important Congress of the I.A.F. held in Rome in September, 1956.

It is the unanimous opinion of the delegates to the Rome Congress that a significant stage has been reached in the development of the I.A.F. It has been a memorable congress for many reasons. For the first time discussion referred to projects that are actually being done rather than to things that could be done if a favourable attitude could be created in official quarters. There was ample evidence that the bold action of the American Government has aroused world wide interest and admiration for their direct and practical approach to the Satellite project. It is obvious that they are looking forward to an increasing measure of international co-operation, rather than to the anticipation of intensified international competition. It is their declared intention to make available to the world at large as much as possible of the information they hope to gain, in the hope that other Governments will do the same. These circumstances gave particular point to the decision of the delegates to admit the representatives of the Russian Academy of Science to full membership, and the subsequent decision to elect Professor Sedov to be one of the two additional Vice-Presidents provided by an amendment to the Constitution, as approved at this congress. It had previously seemed very unsatisfactory that such an influential body should be denied representation in an avowedly international organization because of a constitutional technicality, especially since it was announced at the Barcelona Conference that Russia intends to proceed on parallel lines to the American project by launching her own Satellite Vehicles during the forthcoming International Geophysical Year.

Further good news came with the announcement of the Representative for International Affairs, Mr. Andrew G. Haley, that observer status has been granted to the Federation in respect of the forthcoming U.N.E.S.C.O. Conference at New Delhi. Thus an official link has been established by means of which recognition of the I.A.F. as an accredited Scientific Organization can be realized. This could form a sound basis for a claim to the kind of financial support that must be forthcoming if the I.A.F. is to attempt to fulfil the purpose of its creation on a scale commensurate with the world-wide development in astronautics currently proceeding.

In addition to these substantial causes for satisfaction everyone was impressed by the excellent results of the Italian Society's preparations. Not only was there abundant evidence of much hard work by the Society's members, but there was an impressive display of official interest and participation. The Italian Air Ministry, the Ministries of Defence and Education all had representatives attending the opening ceremonies, and sent messages of goodwill and encouragement. The mayor of Rome and other civic dignitaries were present, accompanied by a variety of police guards, and the display of uniforms was on a scale that made it seem almost incorrect to be present in civilian clothes. One was pleased to note that many of these official participants attended subsequent sessions and appeared to be following the papers presented with interest.

The meeting place itself was striking. The Esposizione Universale Roma (E.U.R.) is a special Exhibition City a few miles outside Rome. Its construction was initiated during the closing phases of the Fascist régime as a physical symbol of the rejuvenation of Italy, and was carried out in a manner calculated to obtain this effect. It has been continued since as a permanent Exhibition Centre. Hundreds of acres of magnificent contemporary buildings are carefully disposed about the site, and the "Palazzo di Congressi" is not the least notable of them. Although unashamedly ostentatious, and very self-conscious, the Italian feeling for architectural composition has created a very fine effect in the grouping of the buildings against a setting of statuary, colonnades and terraced approaches, tree-lined avenues and open squares.

The hall itself provided excellent accommodation, and provision was made for simultaneous translation into four languages by a team of translators housed in soundproof cubicles on a gallery at the rear. Each seat in the auditorium was fitted with a headset and switchbox, by means of which one could select the language one desired. The seating arrangements for the delegates themselves left much to be desired, for it was impossible for the President to obtain a direct view of each delegation. Our own delegation was fortunate in this respect as we, and our Secretary, Mr. L. J. Carter, who was representing South Africa, were among the few delegates who could reckon to catch the President's eye when required; a fact which enabled us to play an active part in the proceedings. The fact that English is the official language of the I.A.F. was of great assistence. Our language is so compact compared with the continental languages, that the translators had difficulty in rendering it in Italian, say, where it seems to take three times as many syllables to express the same facts.

Unfortunately, as with all occasions of this kind, too much time was taken up with the ceremonial preliminaries, so that much of the business had to be deferred to next year, and many more important issues were inadequately debated. This is not good enough when one considers the time consumed and the total cost to each society of the attendance of an adequate delegation. One feels inclined to wonder whether the results achieved are comparable with the costs involved. The various members of our delegation felt so strongly about this that we called a special Council meeting on the spot to consider a communication to the Secretariat proposing modifications of the procedure. The Council is following this up and intends to press for a reform.

The necessity of obtaining access to a live microphone before becoming audible had two results. There was no cross-talk, but there were sometimes delays while the various channels were being sorted out. This made many of the items tedious. The whole proceedings of the Conference were tape recorded, but unless Mr. Stemmer has been unusually lucky the task of unscrambling the records will be formidable.

In an endeavour to "crowd in" a very full technical programme so that it did not clash with the business meetings, inadequate time had been left for either, and this is an administrative problem that must be faced more realistically at future congresses, perhaps by arranging for alternative delegates. By co-operation with the C.I.T. the Italian Society had laid on some very interesting excursions ostensibly for "the ladies".

The fact that the Congress was being held outside Rome made it necessary to provide facilities on the spot, and this had been done. There was a "bar" open all day, a Bank, and Press Rooms with telephones and typewriters available. The latter had continental keyboards which took a bit of getting used to. Outside the auditorium there was a large "Concourse" fitted up with enquiry desks and plenty of chairs. It was generally well populated, and was a favourite place to waylay people whom one was seeking. There was a constant flux of pressmen pursuing delegates for statements and so forth, and there were exhibition stands displaying photographs which could be bought. These showed the various delegates in conversation with one another, and the permutations were completely expended. The rate at which these photographs proliferated was astonishing.

Two of the official outings were an unqualified success. The most important of these was the visit to Castelgandolfo for an audience with the Pope, which almost everyone attended.

It was an excellent trip through the Alban Hills and a tour of the Castelli Romano. Apparently the appellation "Castelli" applies to any hill village, and those we visited were in a sad condition of disrepair, but were certainly picturesque. It appears that the Italians normally are prepared to inhabit buildings which would be regarded as uninhabitable elsewhere. The fact that these buildings are slightly transparent to the weather is less important when the weather is so consistently good. These hill villages are a photographer's paradise, and one was rarely out of earshot of the camera click whenever the coach stopped. Castelgandolfo was very picturesque, and the Pope's palace was a charming relic of the mediæval splendour of the Vicar of Christ. From the moment of ingress we were shepherded by a very adequate retinue of Papal officials, some in frock coats, others in clerical garb. The latter pounced immediately upon any photographic equipment and took it into custody. This was not because it was irreverent but because a gentleman in a special frock coat had got the contract, and conducted his operations with a skilful blend of piety and expertise.

The audience chamber filled rapidly, and two Cardinals in cerise-brocaded jackets and knee breeches, assisted by Professors Crocco and Eueler, sorted out the leaders of each delegation for positions in the front row. The delegates were seated on hard forms awaiting the entrance of the Pope. Facing them was the throne mounted on a low daïs. On either hand stood one of the Papal Guard clad in a truly chromatic livery of scarlet, blue, and yellow strips hanging loosely over an undercoat of red. They were ruffed and helmeted, with poignards in their belts, and armed with halberds. After a short delay the doors opened and His Holiness entered. He walked briskly, and seemed poised and alert. There was a gentle assurance in his manner which gave him great dignity. After a brief utterance in Latin he took his seat and we resumed ours. It was immediately apparent that he was very well informed. He spoke a very clearly enunciated French in a modulated tone that was penetrating but pleasant, and bore the merest suspicion of the chanting lilt common to Churchmen. The summary he gave of the development of Astronautics was as lucid as any I have heard. He traced the subject through its early stages, referring to the work of Goddard, von Braun, and the development of the Viking and Aerobee from the warlike V-2s. He concluded his address with the following words:

"*Finally on July* 20, 1955, *the United States officially announced that they would launch an artificial Satellite during the International Geophysical Year.*

"*You have emphasized, gentlemen, that this present Congress had a particular importance. Beside the artificial satellite the Geophysical Year will be the occasion for the launching of numerous rockets in order to explore the upper atmosphere. This great effort of international collaboration, and the feeling of accomplishing a work highly beneficial to humanity invites you to proceed with great optimism. Innumerable practical difficulties still remain to be solved and you will have to conquer them one by one, with all the resources of modern technology—amongst them the remarkable electronic computers, which reduce to an extraordinary degree the duration of mathematical computation. But in addition you do not hesitate in considering at the present time the more general problems which are posed by the conquest of interplanetary space; and moreover, as appears from documents which you have given us, some of you have*

[*Photo: K. W. Gatland*

Throughout the Congress, Prof. Sedov was constantly invited to comment on Soviet satellite activities, without success. Here, Prof. Sedov is seen with Mr. L. S. Strickson, Secretary of the Yorkshire Branch of the Society.

[*Photo: K. W. Gatland*

After the audience with the Pope at Castelo Gandolfo, a quiet smoke and a chat (*left to right*—J. Venturini (France), R. A. Smith and L. J. Carter)

already examined the abstract possibility of interstellar flights, which the name of 'Astronautics' itself implies as the ultimate goal of your work.

"Without going into details, it is clear to you, gentlemen, that a project of such gigantic implications embodies some moral and intellectual aspects which it is impossible to ignore; it postulates a certain conception of the world, its meaning and its finality. Our Lord, who has given the heart of man an insatiable desire for knowledge, did not have the intention of setting a limit to his efforts of conquest when he said 'Subdue the Earth' (Gen. 2.28). All creation has been confined and offered to the spirit of Man, for him to penetrate it and therefore be able to understand more and more fully the infinite grandeur of his Creator. If, until now, man felt, so to speak, confined on the Earth and had to content himself with fragmentary information which he could get from the universe, it now seems that he is offered the possibility of breaking through this barrier and gaining access to new truths, and to a new knowledge which God has placed profusely in the universe. The sole motive of curiosity of adventure would never suffice to orientate correctly efforts of such magnitude. Conscience must face the new situations which are brought about by the intellectual development of humanity; man should go deeper into his knowledge of himself and of God in order to find his proper station in the universe with more certainty, and in order to appreciate better the meaning of his acts. This common effort of all humanity towards the pacific conquest of the universe should contribute to impress more and more on man's conscience the sense of community and solidarity, for all of them to become increasingly aware of the impression of constituting the great family of God, of being children of the same Father. But in order to penetrate this truth as much respect for truth, submission to reality, and courage is needed as for scientific research. The most audacious explorations of space will only serve to introduce among men a new ferment of division if they are not accompanied by a deeper moral reflection and a more conscientious attitude of devotion to the superior interests of humanity.

"We sincerely wish, gentlemen, that the present Congress takes you further along a long and difficult road, and we should want above all that the magnitude of the spiritual discoveries of which it will be the principle, be no second to scientific knowledge. In seeking for you the protection and favour of God who has created the universe for Man, and who wants thereby to be known and loved by Man, we give you as token for yourselves for your families and for your collaborators, our Apostolic Benediction."

After the benediction he descended from his throne and the heads of delegations were formally presented to him. He spoke a few words to each, in their language, and then spent some time speaking to others who were presented to him. A great crowd pressed round His Holiness and many present, especially the ladies, were much moved, and made humble submission to him, kneeling and kissing his ring.

After His Holiness had withdrawn, Professor Crocco circulated amongst the delegates distributing Holy Medals to all who asked. We moved to the window and from the balcony looked out across a peaceful lake hundreds of feet below, filling what must evidently have been the crater floor. It was very beautiful and we moved, with some reluctance, back into the ordinary world.

On the return we made two stops, one at Grottaferata for lunch and the other at Frascati. Neither place was particularly notable. This may have been because of a feeling of anti-climax, for we all agreed that it was good to know that our work had at last found acceptance in so influential a quarter. For this one must pass credit to Professor Crocco.

The official banquet was another unqualified success. It was held in one of the famous Palazzi that has now become a national art gallery. A suite of rooms had been set aside for the occasion, and the two reception rooms were impressive in the extreme. One of them had an astonishing ceiling by Bernini, one of Michealangelo's pupils, and was an artistic "Tour de Force" of great beauty and skill. The banquet itself was held in two communicating rooms adjoining. There must have been more than three hundred guests seated at small tables arranged about the two beautiful Renaissance rooms. World famous pictures surrounded us, and the room was lit by graceful Venetian cut glass chandeliers. The overall effect was splendid. At the conclusion of the banquet there were speeches, first by the retiring Vice-President, Fred. C. Durant III, followed by a longish but amusing speech by Professor Crocco. This was translated by his daughter with amazing skill. This was followed by a speech by the new President, Dr. Leslie R. Shepherd, in a comparatively short but effective speech. Mrs. Shepherd was presented with a floral tribute which she received with a grace and charm that pleased everyone, especially the British delegates.

There is little doubt that the setting and arrangement of this function set a standard which it will be difficult for any future host Society to improve upon.

It would be inexcusable to omit mention of another outstanding excursion arranged for the final Sunday by the Italian Society in collaboration with the C.I.T. This was a whole day tour to Pompeii and Naples, with a cruise round the Bay of Naples and concluding with a reception at what is now the Museum of Naples. Cocktails were served in a lovely quadrangle as evening fell, but owing to the full programme no time was reserved for a meal to follow, and delegates had to make their own arrangements for a scratch meal to mitigate the effects of the cocktails. We returned to Rome about midnight, with only a few hours to spend, in my case, before boarding the plane for London. I spent these in reviewing the events of the week while I strolled around the city for a farewell look at it in quieter mood.

The very first day came back to mind, when the preliminary meeting of delegates met to confirm the arrangements, in a conference room in the Air Ministry building in the University city. A special quarter of Rome that has been laid out in a modern style as a civic entity, and

J. Stemmer, (Switzerland) I.A.F. Secretary

Behind: A. Haley, (U.S.A.)

Pope Pius XII

F. C. Durant III, I.A.F. President

Prof. Crocco, Associazione Italiano Razzi President

Ralph A. Smith, B.I.S. President

G. V. E. Thompson

F. C. Durant III, (U.S.A.) (I.A.F. President, 1953-56)

Mr. Fiszdon, (Poland)

Prof. Sedov, (U.S.S.R.)

is, in my view, very successful. One passed on to the Inaugural Reception at the C.I.T. offices, an imposing suite on the North quadrant of the Place Esadra, which had been decorated with an enormous streamer announcing the Congress to the world at large. One thought of the banners which had spanned many of Rome's main thoroughfares during the Congress week. No Roman citizen could fail to have known of the Congress unless he were blind. As I walked about the now quietened city I assured myself that I must return one day to enjoy at greater leisure the wealth of ancient monuments, the noble architecture, and the treasures of art which are so essential a part of the Eternal City. I had been greatly impressed by the way that the Romans live in their city. Their social life is brought out into the streets of Rome because it is possible, after a hot and tiring day, to look forward to a bland evening air, and meeting one's friends strolling about until the early hours of the morning, or sitting at the sidewalk cafés awaiting the arrival of a casual friend. It was a pleasant feature of one's stay in Rome, that one had only to take a seat at a café table and wait a little, and someone would pass by that one knew, and sit down and start a party. Too much of the writer's time was spent that way, making new friends and renewing old acquaintances, for there to be time to see enough of the city. It was all so familiar because so famous, yet so exciting to visit in actuality. To stand in the Forum; to visit St. Peter's, or the Coliseum; to ascend the Spanish Steps to the top of the Pincio and stand on the terrace of the park of the Villa Borghesi and look out across the floodlit city to the brooding dome of St. Peter's in the distance, beyond the brilliantly lit Plazza di Popolo at one's feet.

As I walked about the quiet streets and heard, for the first time, the cheeping of the cicadas hiding among the trolleybus wires and in sheltered crannies of the buildings, I realized how boisterous and noisy the city was in daytime to cloak so effectively one of the most penetrating sounds in nature.

It was indeed a memorable Congress.

The Astronomical Widow

By MARGARET W. L. CROSS

Although I had sufficient scientific education to raise me above the Three Little Men on a Flying Saucer school of thought, when it comes to Astronomy and Space exploration, I am the complete Philistine. I do know that Saturn is "the one with the rings", but so indeed does my seven-year-old son.

So when my husband became immersed for long hours in his work-room in grinding a mirror for his six-inch telescope, I merely tolerated the eeh-ah, eeh-ah which seemed to my tortured senses to go on for weeks on end.

When the telescope, in all its glory of grey paint, was carried downstairs and out to its viewing position in the back yard, I cast but a cursory glance at it, long enough to recognize a certain saucepan lid which had disappeared from the shelves a few weeks before.

Then I retired to bemoan the newly-scarred walls of the hall and staircase. But alas, that was only the beginning.

The local Press got wind of the magnum opus, and we were invaded by crouching figures with flash bulbs, to whom I administered coffee and cake at suitable intervals. The resulting picture showed the telescope (saucepan lid rampant) and a moronic-looking type whom I assumed to be my husband.

That publicity led to a whole series of strange visitors, who descended upon us at all hours of the day and night —particularly the night, muffled up to the eyes in suitable viewing costume. There was one good result of all this. I became quite expert at cake-making. Often when I returned from my Council meetings I would receive a shock. There, in the dim glow from an electric torch, I would see several hunched figures, muttering together over the eye-piece, and I would creep like a thief into my own house, tripping over the flex as I did so.

But as time went by, the novelty wore off, and all but the really keen were seen no more. Then came the article-writing stage.

Just as I was thinking of taking myself off for a well-earned rest, a sheaf of papers which "must catch the first post in the morning" would be thrust under my weary gaze. On the strength of an English prize in college I am considered sufficiently intelligent to spot spelling mistakes, correct punctuation, and generally to tidy up split infinitives and the like.

I still suffer from my first misguided zeal. In vain do I protest that my mind just will not function at such a late hour. Reluctantly I plod through the pages, correct for the umpteenth time the incorrect spelling of "achieve"—a favourite word, and retire in a bemused whirl of equations and occultations.

My services are infrequently sought over the translation of French scientific papers which comes reasonably easily to us both.

German is a different matter. The examining bodies generally do not require senior pupils of Grammar schools to be familiar with such words as, "auspuffungsgeschwindigkeit", but after much trial and error, we finally work out between us that it means "exhaust velocity". Luckily German is a direct sort of language —a telescope being a "far-tube", which anyone can see is logical enough. So eventually, all is understood, if imperfectly by me.

There are compensations. At least I know where my men-folk are, which is more than can be said for the golf-widow, the pub-widow or the fishing widow.

Just now, we are awaiting the arrival of a large lump of Pyrex to be used in the construction of a twelve-inch mirror. Excuse me, there is the postman. Yes, as I thought, a large heavy box. Here we go again.

Progress Towards Spaceflight

A Review of the Technical Papers presented at the Seventh International Astronautical Congress

By G. V. E. THOMPSON, B.SC., A.R.C.S., F.R.I.C., L.I.M.

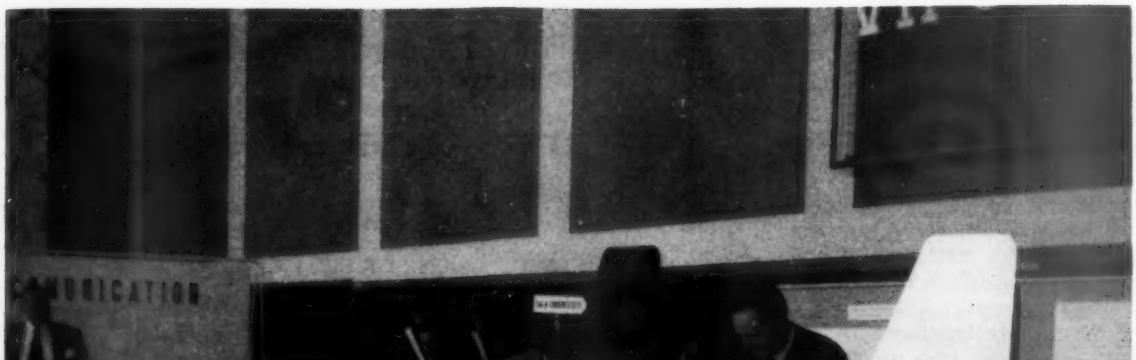
At the Seventh International Astronautical Congress held in Rome from 15th to 22nd September, 1956, forty-three papers were presented at the various technical sessions, and several other prepared contributions were given in the short time allocated for discussion. It is convenient to consider the papers as falling into two groups. Approximately one-quarter of them dealt with artificial satellites of one type or another, and were therefore of especial interest in connection with the International Geophysical Year (I.G.Y.) programme due to start next July. The remaining three-quarters covered a variety of topics ranging from the "digestive processes" of rocket motors to such flights of fancy as journeys to other stars.

I.G.Y. Artificial Satellites.

Two countries—U.S.A. and U.S.S.R.—have announced their intention to launch artificial satellites of the Earth during the I.G.Y. No information is available concerning the Russian satellite, except the claim that it will be "better than the American one". A Russian delegate, Professor Sedov of the Astronautics Group of the Astronomical Council of the U.S.S.R. Academy of Sciences, was present at the Congress, but when questioned about the Russian programme, he said that he knew nothing about it. Much is known about the U.S. satellite programme (Project Vanguard), however, and at the Congress the launching vehicle was described by N. E. Felt, Jnr. In addition, a press conference on Vanguard was held by Lieutenant-Commander Patricia Grace Conwell, head of the Public Relations Office of the U.S. Naval Research Department (incidentally, the Italian newspapermen were surprised and delighted when this charming lady's rank was explained to them). Most of the information given by Mr. Felt and Miss Conwell will already be familiar to readers of *Spaceflight* from Mr. Gatland's article on the Vanguard Project in the October, 1956 issue, so that there is no need for me to repeat it here.

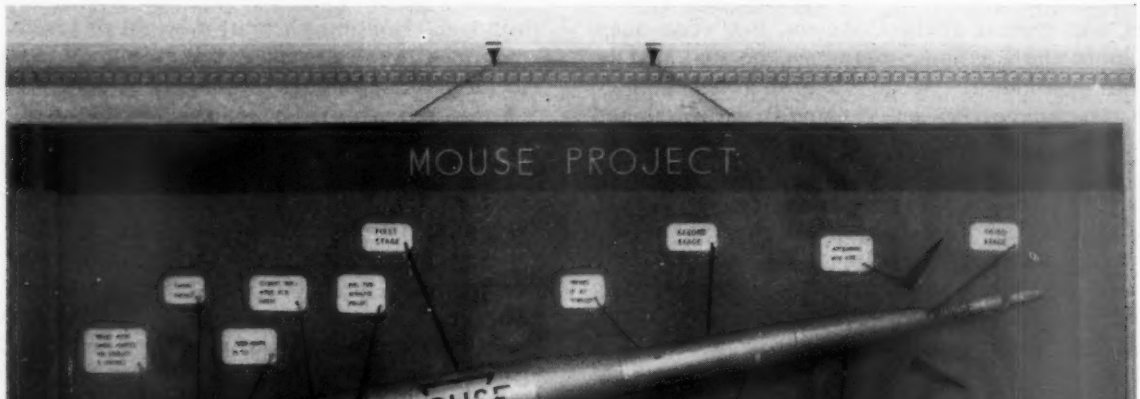
This article also referred to the MOUSE project of Professor S. F. Singer of the University of Maryland. Together with D. T. Goldman, Professor Singer has continued his work on MOUSE by studying the radiation equilibrium of such a satellite; their results are given in the form of nomograms which enable the equilibrium temperature of a satellite to be predicted. Professor Singer also showed some of the miniature instruments developed for use in high-altitude research. Even smaller instruments and components are being devised for the Vanguard satellite, because of the severe restrictions on size and weight which it necessitates. The satellite itself is to be a 20-inch sphere of magnesium alloy weighing about 4 lb., but its total weight when packed will be 21½ lb. As it is, over half its "payload" of some 17 lb. will be made up of the radio and batteries, so that little is left for the measuring instruments. A single satellite would be quite unable to carry all the instruments which scientists want to send aloft, even when they are miniaturized, so they will have to be distributed over a number of attempts. A system of priorities has been established, and the construction of twelve launching vehicles has been authorized.

Some of the uses to which the satellites will be put are the measurement of the temperature, pressure and density of the high atmosphere, the cosmic ray intensity, and the Earth's magnetic field. J. J. King considered its use in studying upper atmosphere temperatures, and M. Dubin discussed how it could be employed to investigate "cosmic dust"—interplanetary matter entering the Earth's atmosphere. Even without instruments the satellite could give much useful information. It will not continue to circle the Earth in the same path for ever; although the atmosphere at a height of several hundred miles is extremely rarefied, it is able to exert a resistance to the passage of the fast-moving satellite. As a result of this atmospheric drag, the satellite will gradually spiral in towards the Earth; in doing so, it is entering less rarefied regions of the atmosphere, so that the drag is increasing and the tendency to fall back to the Earth becoming progressively greater. In addition to these changes in the path of the satellite, there will be other variations in the orbit caused by the oblateness of the Earth (i.e., its flattened shape, the diameter from pole to pole being less than the equatorial diameter) and by peculiar distributions of mass. Thus, the attraction of the Earth for the satellite will be greater when it passes over a continental area than when it is passing over the oceans. The presence of heavy ore deposits can cause similar variations. If the orbit of the satellite can be recorded accurately, then it will be possible to estimate both the density of the atmosphere and the mass distribution of the Earth. This would be done by making various assumptions about these quantities, calculating the orbit that would result from each set of assumptions, and comparing these theoretical orbits with the actual one, to see which set of assumptions best fitted the facts. Two independent papers—one by John DeNike of the Glenn L. Martin Co. (the principal contractor for the



[*Photo: K. W. Gatland*

K. W. Gatland (*left*) and L. S. Strickson discuss features of the Aerobee rocket in the reception hall of the Congress Palace



A general view of the display panel showing a model of a three-stage satellite rocket, based on the British design study of 1951

Vanguard launching vehicle), and one by J. M. J. Kooy of Holland (co-author of the book "Ballistics of the Future")—dealt with mathematical methods of calculating the theoretical orbits. DeNike obtained mathematical equations which could be solved by using an IBM high-speed digital computer, and gave examples to show the results of calculations based on various assumptions. He had verified that other possible perturbing agencies (the attractions of the Moon and the Sun, the Earth's magnetic field, meteoric particles, etc.) would have a negligible effect upon the satellite's motion. H. Krause of Germany also discussed the various perturbations of an artificial Earth satellite.

In this way, the satellite programme should yield information about the shape of the Earth as well as about our atmosphere and conditions in interplanetary space. The branch of science which is concerned with the Earth's shape is termed geodesy; one interesting geodetic result that might follow is that distances between various places about the globe could be estimated much more precisely. Such knowledge might be useful in some circumstances, although for ordinary purposes (navigation, cablelaying, transport by roads or rail, etc.) the present data is probably sufficient.

Vanguard Satellite Tracking Programmes.

There are two methods of following the motion of the satellite—by radio and optically. A large part of the pay-load of the sphere will consist of radio equipment, necessary to relay the data obtained by the instruments back to the ground, since the satellite will be destroyed as it returns into the denser layers of the atmosphere. By using a triangulation system to receive the radio signals, the position of the sphere at any instant can be calculated. A similar record of position can be obtained by visual methods; twelve 20-in. Schmidt cameras are to be used in U.S.A. for this purpose and observatories elsewhere are expected to co-operate. The visual observations will be of great importance when the satellite is approaching the end of its life, for then radio tracking is likely to be impossible, owing to exhaustion of the batteries or failure of other components. In the event of a premature failure of the radio, the full weight of responsibility for the critical initial observations of the satellite might fall on the optical observers. Moreover, the possibility that a satellite may be launched without a self-contained radio cannot be entirely ruled out. The The U.S. National Academy of Sciences, through the National Science Foundation, has assigned to the Smithsonian Astrophysical Observatory the task of initiating the optical tracking programme. Dr. Fred L. Whipple, Director of the Observatory, explained the arrangements. The photographic Schmidt telescopes will make precision observations, but it is intended also that amateur astronomers (and radio "hams") will participate. They will have to be competent and equipped with suitable instruments (*large* binoculars or a telescope, together with a precision timing system) and organized into teams so that a continuous watch can be maintained during the intervals when the satellite is visible. These will occur just before sunrise and just after sunset, i.e., when the Sun is below the horizon (so that the sky is dark) but the satellite is not eclipsed by the Earth's shadow.

The visual observing programme has been given the code name MOONWATCH (the satellite will not of course present to us an image as large as our own Moon —it will look like a faint star moving at an appreciable rate—but it will be an artificial moon of the Earth, so the name is quite appropriate. Professor W. H. Haas describes the programme elsewhere in this issue of *Spaceflight*). Dr. Whipple hopes that the various astronautical societies will assist by organizing the teams of volunteer observers in their respective countries. I represented the British Interplanetary Society at a committee meeting which he held to discuss this, and he asked the B.I.S. to do what they could in organizing teams in Australasia, India, and Britain itself. Actually, the teams in Britain would be the least important, since the first Vanguard satellites are to travel in orbits lying wholly within the 40° parallels of latitude—i.e., their observation from this country would be difficult or even impossible. A near-equatorial orbit is easiest to attain, since the Earth's rotation on its axis makes a contribution of about 1,000 miles per hour towards the required final velocity of about 18,000 miles per hour. However, it is hoped to organize teams in Britain, since it is quite on the cards that later satellite launchings will be made to give other orbits; in addition, any satellite put up by the U.S.S.R. would almost certainly pass much nearer to the poles than the 40° parallels. One probable location of a MOONWATCH team would be at Harrogate, where the Yorkshire Branch of the B.I.S. is establishing a small observatory.

Before the first Vanguard launching takes place, tests will be made to provide experience and to ensure that the various MOONWATCH teams are fully competent. Meanwhile, Dr. Whipple is issuing a *Bulletin for Visual Observers of Satellites*—a periodical intended to give news of the progress of the programme, to discuss methods and means of observation, etc.

The data obtained from both visual and radio observations will be sent to a central computing bureau. H. J. Grosch, of the General Electric Company, U.S.A., presented a paper in which he stated that the electronic computers already available were quite capable of computing the orbit of a satellite in a few minutes or seconds.

Dr. W. B. Klemperer and R. M. L. Baker, Jnr., of the Douglas Aircraft Company, considered the computation of satellite *librations*, i.e., the oscillation or wobbling of the satellite about its equilibrium position, like the pitching, rolling or yawing of a boat. They were interested in determining whether it would be possible to utilize instruments responsible to these librations for navigation of the satellite, but they found that there were serious limitations to any such scheme.

Other Satellite Projects.

Satellites other than Vanguard were also discussed at the Congress. I have already mentioned the MOUSE

project of Professor Singer. Björn Bergqvist, research leader of the Swedish Interplanetary Society, gave a method of designing orbital ferry crewless rockets for minimum launching weight. Aurelio C. Robotti of Italy suggested the launching of orbital vehicles from aeroplanes. As large aircraft have already been used for launching smaller rocket planes, there is nothing inherently impossible in this idea, but the examples depicted in Signor Robotti's paper did not have the appearance of being at all practical. Another Italian paper, by Frederico Romano, discussed the camouflaging of space stations as a defence against attack; this excursion into military matters was not well received, since the International Astronautical Federation has always stressed its peaceful aims and interests. N. V. Petersen (U.S.A.) summarized proposed methods for determining satellite lifetimes and the density of the upper atmosphere. Alessandro Boni of Italy was interested in the use of an Earth satellite for astronomical observations, e.g., by use of television.

The only British paper at the Congress was given by Mr. T. R. F. Nonweiler of the College of Aeronautics, Cranfield. This was concerned with the heating of the skin during the re-entry of winged satellite vehicles into the Earth's atmosphere, and has since appeared in the September/October issue of the *Journal of the British Interplanetary Society*.

There were two contributions dealing with satellites of more advanced types. A Rand Corporation report by R. W. Bucheim was concerned with the requirements for establishing unmanned satellites of the Moon. It has been suggested that this development will take place before *manned* Earth satellites are attempted. The conditions for avoiding both impact on the Moon and recapture by the Earth were determined. It was estimated that if the errors in guidance and control could be kept within one-twentieth of those expected for the Vanguard vehicle, then a permanent, optically-observable lunar satellite could be established in a retrograde orbit (i.e., a path around the Moon traversed in the opposite direction to the Moon's motion around the Earth) by using a vehicle weighing about one million pounds. For a direct orbit (one in the reverse direction around the Moon), this accuracy would again need to be doubled. As there is almost a complete vacuum at the Moon's surface, a lunar satellite would not be subjected to atmospheric drag, and would therefore have almost an infinite life.

The Rand Corporation is not the only U.S. organization interested in such advanced astronautical projects. Many people would prefer to see manned orbital vehicles developed before an unmanned lunar satellite, and from time to time various designs for more elaborate orbital structures have been proposed. These are usually referred to as "space stations" and the reader will probably be acquainted with those designed by von Pirquet, by von Braun, and by H. E. Ross and Ralph Smith (the present B.I.S. Chairman of Council). Yet another scheme has now been devised by a team at the Goodyear Aircraft Corporation and summarized in a fifty-two page report by Darrell Romick. Although this was not originally on the Congress programme Mr. Romick was able to outline his proposals; the project has been given the mnemonic title METEOR (a Manned Earth satellite Terminal evolving from Earth-to-Orbit Rockets). Three-stage launching rockets with a total weight of 9,000 tons would be used, each stage being winged and carrying its own crew. After separation of each of the bottom two steps, their nose slots would be closed and they would be piloted back to Earth for re-use and would land in the manner of an ordinary aircraft (take-off is in the vertical position, the overall height being 285 ft.). This seems a realistic procedure for such an expensive vehicle. The third step (total weight 140 tons) would attain orbital speed, and when sufficient of these had been collected together in an orbit they could be cannibalized to construct a tubular space terminal.

Mr. Romick emphasized that the project was a flexible one, which enabled terminals of any desired size to be constructed, but which could be stopped at any stage. He proceeded to show many illustrations indicating how development might proceed. In its initial stages, the scheme seemed fairly plausible: a series of third-stage vehicles were joined together, nose-to-nose and tail-to-tail, to form a nine-foot diameter tube. However, this tube was then made to become the "axle" of a great wheel built at one end of it. Next, concentric cylinders were built around the original tube—first, one 75 ft. in diameter; finally, one 1,000 ft. in diameter—until there resulted a very large structure 3,000 ft. long, 1,000 ft. in diameter, rotating about the original "axle". The cylinders were subdivided to provide offices, docking facilities for orbital ferry vehicles, workshops, hotels, a tube railway, a church, a supermarket, etc. By the time this stage was reached most delegates were becoming incredulous and wondering if the project were not going to end up with the whole of Texas in orbit about the Earth. Yet it would be unfair to judge the whole scheme by Mr. Romick's final example—the initial stages of the project deserve more detailed consideration. Even so, it would seem that in view of the fact that even the $21\frac{1}{2}$ lb. Vanguard sphere is not to be launched for some months at least, Mr. Romick's ferry rockets might well need more than the fifteen years suggested as necessary for their development.

Space Medicine.

Before manned flight beyond the atmosphere takes place it would be desirable to increase our knowledge in the medical and biological fields. Four papers dealt with these aspects.

One of the peculiar conditions encountered in space will be weightlessness. This will be met with when a rocket or other vessel is not operating its motors but is just moving freely in the vacuum between the planets. The speed of the vehicle does not matter; all that is necessary is that the ship shall be allowed to respond

freely to whatever gravitational forces are exerted upon it by the various heavenly bodies (for this reason, the rocket is sometimes said to be in a state of "free fall"—even though it may actually be moving away from the nearest planet). Under these conditions, there is no appreciable force tending to pull objects inside the ship towards "the floor". Anything loose will just float around inside the vessel, i.e., will have no "weight". It is possible for similar conditions to arise on Earth, but only for very brief periods of time (on a spaceship, weightlessness might exist for the greater part of the voyage). Thus, when a lift or elevator begins to descend suddenly, the unpleasant feeling in one's stomach is caused by a momentary loss of weight. A similar experience occurs in parachute drops. At the Rome Congress, S. J. Gerathewohl of the U.S. Air Force School of Aviation Medicine presented the results of a series of experiments on weightlessness. A Lockheed T-33 aircraft was flown in dives and parabolas to give periods of practical weightlessness of from ten to thirty seconds. A film taken during the experiments showed that during these periods mercury shaken about in a bottle behaved as if it were water, and that on squeezing water out of a plastic bottle it floated gently around the cabin until the aircraft pulled out of the parabola. Various persons who took part in the flights were asked to record their personal experiences. The majority of the subjects tested found the weightless condition pleasant, a conclusion which was perhaps unexpected. A few subjects suffered disagreeable effects, but others (including Mr. Gerathewohl) were indifferent. It therefore seems that weightlessness will be no bar to the achievement of space travel, although some persons might not be able to participate because of their individual reactions. Whether this conclusion will still be true when the weightless condition can be maintained for hours or days is of course another matter.

Professor T. Lomonaco, M. Strollo, and L. Fabris also reported experiments on weightlessness, made at the Centro di Studi e Ricerche di Medicina Aeronautica, in Rome. In this case, the subject was seated in a cockpit which could be pulled up a tower by means of stretched elastic cords producing accelerations ranging from three times that due to gravity (for fractions of a second) to zero gravity (total time four seconds). The effect on the subject's muscular control was studied by getting him to hit the four quadrants of a circle with a pencil, at a natural rhythm, trying to equally distribute the points. Under these experimental conditions, a slight loss of control was noted and unpleasant sensations were reported by the subject, but in several consecutive runs they became accustomed to the experience.

Perhaps the most important question in space medicine today concerns cosmic radiation. This consists of a stream of high energy particles (probably mostly of solar origin) which bombard the Earth and which are capable of causing cancer and other injuries on striking living tissues. Fortunately for us, the great majority of these particles are intercepted by gas molecules in their passage through our atmosphere. As a result of the collisions, the primary cosmic rays are converted into secondary radiation, and other changes result from subsequent encounters, so the radiation which finally reaches the Earth's surface is much less harmful. Our atmosphere thus acts as a shield against the primary radiation, but when we travel out into space or even merely fly at very high altitudes we shall be leaving this shield behind us. Before we can decide what measures, if any, are necessary to counter the hazards of cosmic radiation it will first be necessary to determine the magnitude of the hazard. At the Congress Major D. G. Simons of the U.S. Air Force Space Biology Branch gave some preliminary results on the effect of heavy primary cosmic radiation. The experiments involved giving small animals, seeds and eggs balloon flights of up to 30 hours' duration at altitudes of about twenty miles. Among the effects observed were injury to nerve cells, and the greying of black mice because of damage to hair pigment cells. The streaks of grey hair were such as to suggest radial spreading of the radiation effects some twenty times greater than the spread which would have been expected. As yet the data are insufficient to enable one to judge the hazards for manned flight in satellites or high-altitude rockets, but the work is still proceeding.

Hubertus Strughold, Chief of the Department of Space Medicine, U.S.A.F. School of Aviation Medicine, presented a paper entitled "The Ecosphere in the Solar Planetary System". The ecosphere is the name given to the zone around the Sun (or other star) within which the intensity of radiation lies between the limits within which life as we know it is possible. In our Solar System, this zone extends from the orbit of Venus to beyond that of Mars, roughly from 50 million to 150 million miles from the Sun.

Methods of Propulsion.

Several authors dealt with methods of propulsion, either conventional or hypothetical. Dr. E. A. De Zubay, Head of the Fuel Section of the Curtiss-Wright Corporation's Research Division, presented a mathematical paper on the combustion processes taking place within a rocket or turbo-jet engine. Another mathematical contribution, by H. J. Käppeler and G. Baumann of Germany, was concerned with chemical reactions. I. C. Corbetta of Italy briefly considered the application of nuclear energy to astronautics. A. Jona of Italy suggested that an additional thrust source for a rocket could be provided by a chemical reaction between the materials making up the body of the rocket, and gave an example in which this type of source was used to propel a fourth step in a modified minimum satellite vehicle based on the proposals of Gatland, Kunesch, and Dixon (*Journal of the British Interplanetary Society*). However, Signor Jona gave no details as to how this thrust source was to operate.

Krafft A. Ehricke analysed the possibilities of using solar power for propulsive purposes. He visualized the

collection of solar radiation from a large area by use of spherical collectors of inflated transparent plastic. One half of each sphere would be metallized. Out in space, only a small pressure would be needed to stabilize the sphere, so that the collector would be of extremely low weight. The radiant heat would be concentrated on to pipes containing a working fluid; after heating, this would pass to an exhaust nozzle. This type of system could only produce low thrusts and would therefore be useful only in outer space itself. Ehricke showed that it would be impracticable for a journey to the Moon; on trips to Venus or Mars the use of solar power would necessitate employing vehicles of much lower weight than would be used with ordinary chemical propulsion.

R. M. Corelli of Italy reported some experimental work in which tetranitromethane and carbon were used as propellants. B. Langnecker of Austria also described some interesting experiments illustrating the effects of unstable combustion in the rocket engine on the properties of metals. These effects would explain the sudden failure of the engines in service. J. Pressman (U.S.A.) considered the implications of some recent experiments (in which nitric oxide gas was released at high altitudes) on possible upper atmospheric propulsion systems using atomic oxygen. The remaining three propulsion papers were all mathematical: H. Bednarczyk dealt with rockets using steam as the working fluid, W. Peschka with the possibility of increasing exhaust velocities by controlling the temperature inside the engine, and H. Ruppe classified all the possible propulsion systems.

Rocket Designs and Journeys.

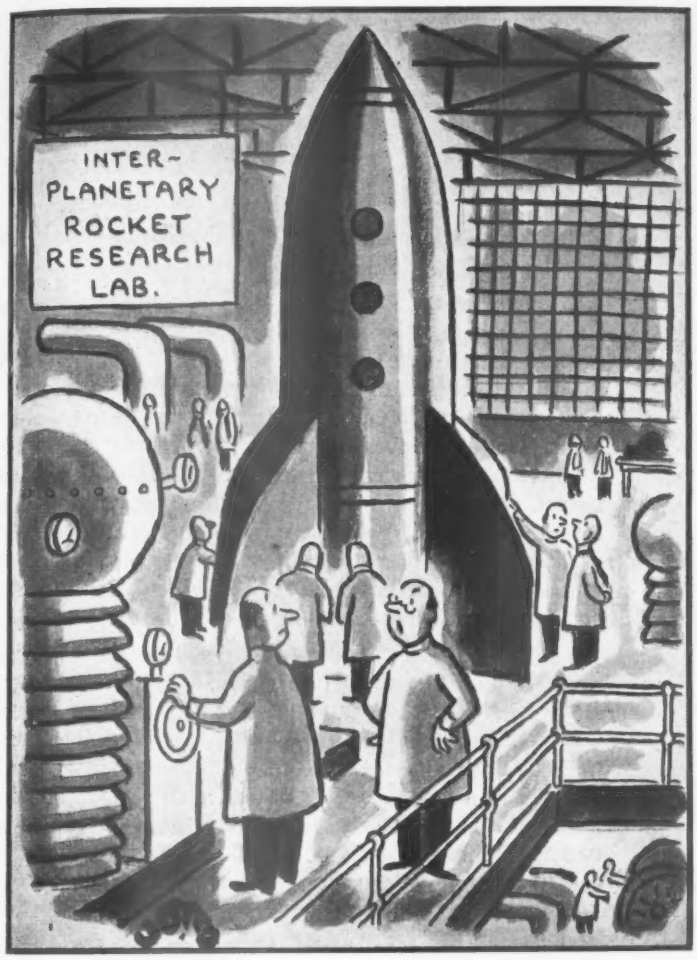
The President of the International Astronautical Federation, F. C. Durant III, read a paper prepared by K. R. Stehling and R. Foster, who were unable to be present. This paper contained an interesting proposal for small lunar rockets. They would be of the solid propellant type, launched at a high altitude whilst suspended from a balloon. This technique has already been employed for studying the upper atmosphere—the combination of rocket and balloon being known as ROCKOON—and the rocket takes off by going straight through the flimsy plastic balloon. For a lunar trip, a much larger balloon or balloons would be needed and the rocket itself would have three steps and a final payload of about four pounds. Rolf Engel of Egypt gave a mathematical paper on the design of step-rockets; another mathematical contribution was that of M. Vertregt, on the effect of errors in the calculated magnitude of the thrust.

Professor General G. A. Crocco, President of the Associazione Italiana Razzi, examined the possibility of a trip to both Mars and Venus within a single year. According to astronomical calculations, a favourable time for such a trip to take place will be in June, 1971. Dr. Eugen Sänger explained how an even more remarkable journey—to other stars—would be possible, although the journey might take hundreds of years. The theory of relativity indicates that at velocities near to that of light, time on the vehicle would be different from that on the Earth, so that in effect the lives of the crew would be prolonged.

Miscellaneous Matters.

Three papers, by Andrew G. Haley, Chairman of the Board of Directors and General Counsel of the American Rocket Society, by Eugene Pèpin, Director of the Institute of International Aerial Law, Montreal, Canada, and by Aldo Armando Cocca of Italy, were concerned with legal aspects of space travel and with the need of setting up laws to meet the situations which must inevitably arise.

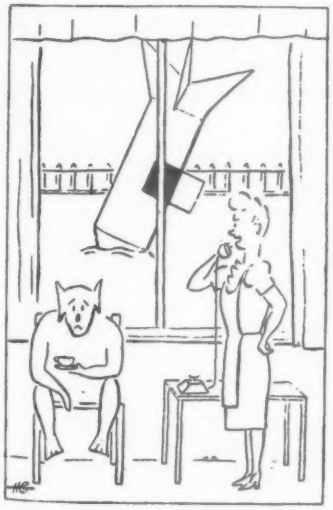
F. Hecht and R. Patzak stated that chemical analysis of microscopic particles dredged up by the 1947/48 Swiss Deep Sea Expedition showed that they contained iron, nickel and cobalt and were of meteoric origin. H. E. Hinteregger and J. F. Bedinger (U.S.A.) read a paper on optical measurements in the ultra-violet part of the spectrum. W. Davis, also of U.S.A., suggested that the usual estimates for the time which will elapse before man's first flights to the planets were much too conservative. J. Gadomski of Poland outlined an astronautical Moon and Planets calendar. The remaining paper to be mentioned was also from Poland: written by K. Zarankiewicz, it was entitled "Konforme Abbildung zweifachzusammenhängender Gebiete", which I translate roughly as "Conformal Representation of Twofold-dependent Regions". As I was absent from the hall on B.I.S. business when this was given, and as no preprints of it were available, I am unable to comment upon it, but I look forward to reading it in the complete proceedings of the congress, which will be published by the Associazione Italiana Razzi, Piazza S. Bernado 10, Roma, Italy.



"For the last time, Benson, will you kindly refrain from muttering to yourself, 'whither mankind, whither'"!—Courtesy of *Everybody's*.

"You were right, Captain—it *is* green cheese"!—*News Chronicle*.

"Your allergy tests suggest you may have been intended for some other planet".—*Saturday Evening Post*.



"Hallo. Is that the Interplanetary Society"?—*Manchester Evening News*.

"Let's look around a bit before we write our books, shall we?"—*New York Times*.

The V2 Power Plant

By A. V. CLEAVER

The German V-2 (or, to give it its official designation, the A-4) of course represented an historic stage in rocket development. It was the first really large rocket vehicle, and the first to achieve a degree of success justifying its use on actual operations of real significance.

Apart from its pioneering effort in the fields of guidance and control, and without any intention of belittling the value of many ingenious features of the vehicle itself, it may justifiably be claimed that the greatest importance of the project lay in its power plant. The heart of any rocket vehicle, inevitably, is its propulsion system, which gives it its essential character and enables it to perform those duties which cannot be carried out by any other type of vehicle.

The V-2 rocket engine was, therefore, the first large example of its kind, with a reasonably high performance (specific impulse over 200 seconds at sea level) and standard of reliability. The magnitude of the achievement should never be underestimated, nor the technical worth of the immense contribution to rocket progress made by the Peenemünde team, by Dr. Wernher von Braun in particular.

The unit had a sea-level thrust of about 55,000 lb. It burned liquid oxygen and a mixture of ethyl-alcohol and water which were fed into the combustion chamber by centrifugal pumps. The pumps were driven by a turbine which operated at 500° C. on steam and oxygen made from 80 per cent. hydrogen peroxide. The peroxide was fed by compressed nitrogen from a small auxiliary tank into a separate gas generator, where it was catalytically decomposed by calcium permanganate granules to give the mixture of superheated steam and oxygen.

The combustion chamber pressure was rather low by present standards, less than 250 lb./sq. in., but the gas temperatures attained were quite formidable—about 2,700° C.—even though the oxygen/fuel ratio chosen did not give the highest temperature possible from the propellants. Refined methods of cooling were therefore introduced; the chamber was not only regeneratively cooled by the ethanol/water fuel flowing round it in a coolant jacket, but a proportion of this fluid was also bled, through rings of holes, to give evaporative or film cooling on the hot gas side of the chamber walls.

The chamber itself was of welded mild steel construction, and the fuel was ignited in the first instance by a ground pyrotechnic device—rather like a Catherine wheel placed inside the chamber.

When running at full thrust, this chamber consumed about 30 gallons of propellants per second, giving a specific impulse (thrust in pounds for each pound of propellants burned each second) of about 200. The fuel tank was lightly pressurized by nitrogen gas, to prime the pump and prevent cavitation at its inlet; a similar function was performed for the oxygen side of the system by the vapour pressure of this oxidant itself, raised to the required value by evaporation of a bleed in a heat exchanger run off the turbine exhaust. The turbine itself developed the horse-power needed to pump the two propellants into the combustion chamber.

The photographs reproduced here show a typical trend in engineering development, with the prototype (Fig. A) looking something of an improvised mess, while the production unit (Fig. B) is considerably tidied up. Even so, it may still appear to some as rather a "snakes nest" of pipes—as is practically inevitable in a rocket power plant. Remember that the V-2 employed two main fluids, two auxiliary fluids, and auxiliary gas pressurization systems, with the turbine exhaust to be disposed of, as well as the main jet!

It is interesting to reflect that the V-2 rocket engine, now about 15 years old in its original conception, is still the largest and most advanced engine about which really detailed information has been published. We may be sure that in the U.S.A. and the U.S.S.R. at least, larger and more advanced engines have since been built. Apart from the mere increase in size, improvements may be expected to have been made in other directions, such as reduction in weight; simplification, by improved detail design particularly with regard to chamber construction; the development of cooling methods to permit operation at higher gas temperatures; and probably more powerful propellants, such as gasoline, or kerosine, and oxygen. Turbopump systems may have been improved, perhaps using the main propellants instead of introducing the complication of auxiliary fluids.

Yet despite all these likely refinements, the original V-2 engine remains as a remarkable anticipation of nearly all possible subsequent work.

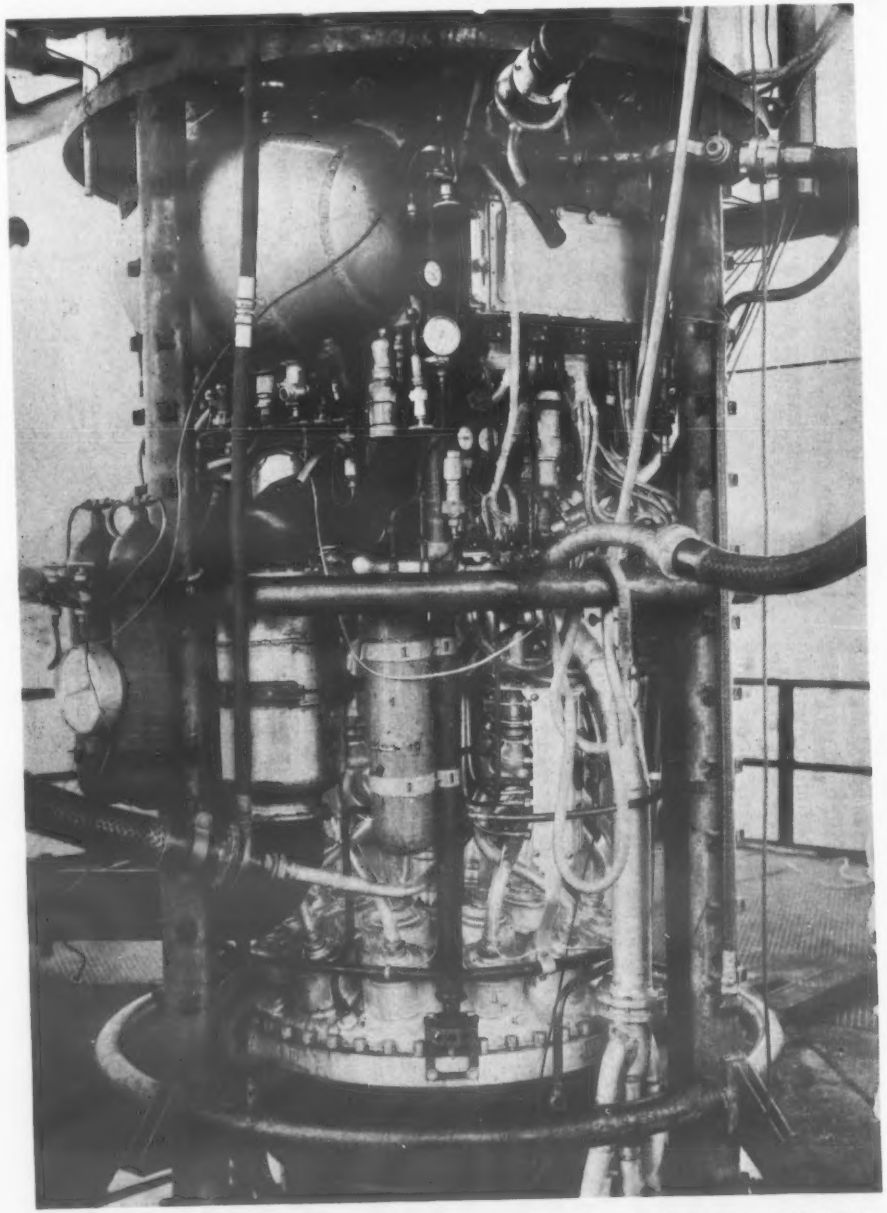


FIG. A. A-4 powerplant during development stage ("plumber's nightmare"), 1941

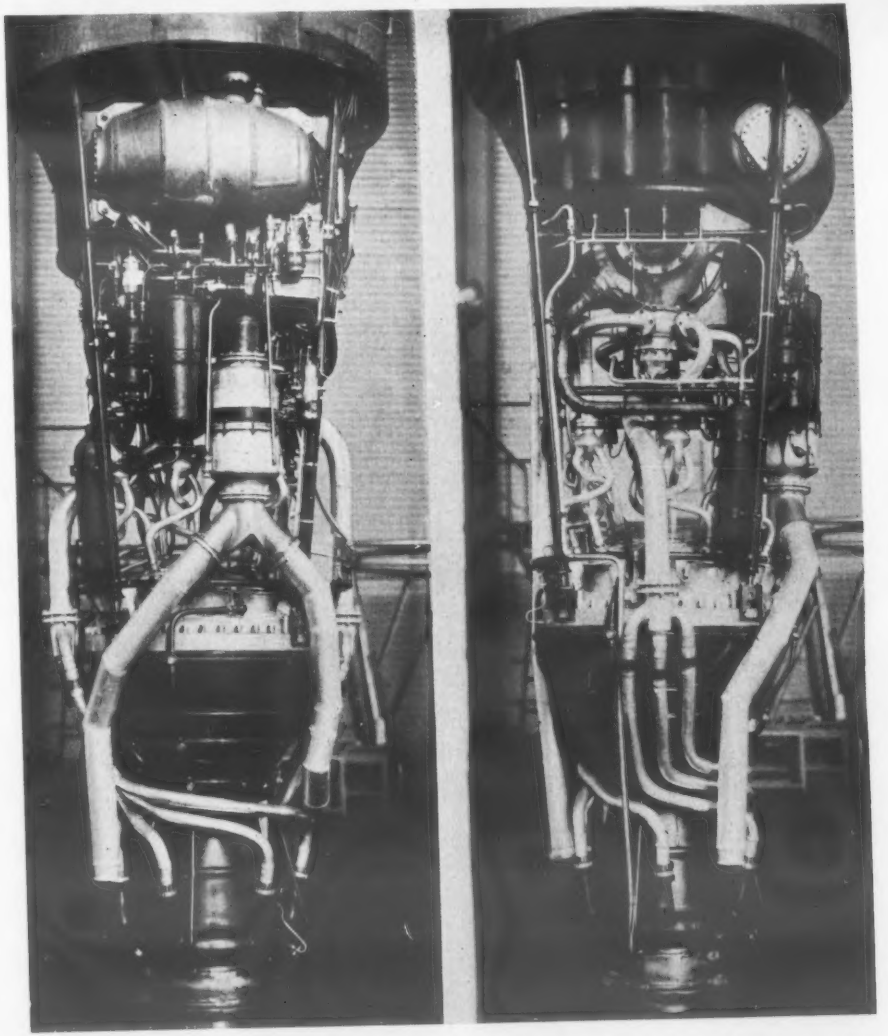


FIG. B. A-4 power plant as it went into production. In the L.H. picture, the hydrogen peroxide tank can be seen at top, with the turbine exhaust/oxygen heat exchanger below it, and the small permanganate tank slightly to left of that. The split turbine exhaust pipes lead down to the vicinity of the main chamber nozzle exit, at bottom.

In the R.H. picture, the nitrogen cylinders (with peroxide tank at extreme right) are seen at top. The turbo-pump assembly, with its gas generator, is below these components. Note also the various auxiliary alcohol/water lines, leading into the film-cooling manifolds on the main chamber at the bottom of the picture.

Sky Diary: January to March, 1957

By PATRICK MOORE, F.R.A.S.

It is remarkable how many people—including some who are genuinely interested in space-flight—are unable to pick out even the most conspicuous of the star-groups. This seems a pity, since the various constellations become much more interesting when they can be recognized at a glance. Moreover, it is easy to confuse a planet with a star, unless one has at least a reasonable knowledge of the night-sky. (I remember being rung up at four o'clock in the morning by an enthusiastic amateur who said that he had discovered "a bright new star" in the constellation of Gemini. It proved to be the planet Saturn.)

Winter is clearly the best time for star-watching, partly because the evenings are dark and partly because the visible constellations are brilliant. Pride of place must go to Orion, the Hunter, shown in the diagram. The characteristic shape—a rough quadrangle, with the "Belt" running diagonally—is very obvious; Orion can be seen in the south during January evenings, and it can hardly be mistaken.

The stars are graded into classes or "magnitudes" according to their apparent brilliancy; the lower the magnitude, the brighter the star—the faintest stars visible without a telescope are those of about magnitude 6. On this scale two of the Orion stars, Betelgeux and Rigel, exceed magnitude 1, and the remaining stars of the quadrangle and belt are magnitude 2. Modern methods enable these magnitudes to be measured very exactly. Rigel, for instance, is 0·08 (though many books still give the old value of 0·34); Sirius, the brightest star in the sky, is −1·44, so that its magnitude has a negative sign.

It must be remembered that these apparent magnitudes have no direct connection with the real brilliancy of the star. Rigel is exceptionally luminous, and shines with 21,000 times the candlepower of the Sun; Sirius is only 26 times as bright as the Sun—yet in our skies Sirius appears the brighter of the two, simply because it is much nearer.

There are many interesting telescopic objects in Orion. Below the "Belt" can be seen the misty patch in the "Sword", known as M.42 or the Great Nebula. This vast gas-cloud is well revealed in a low-power telescope, along with the multiple star Theta Orionis. Also in Orion can be seen the "Horse's Head" dark nebula, well shown in the photograph. There is no essential difference between a bright and a dark gaseous nebula; it is merely that the latter is not rendered luminous by associated stars.

Orion can be used as a kind of "celestial signpost", and will enable other stars to be identified. The Belt stars point "downwards" (according to northern hemisphere standards) to Sirius, and "upwards" to Aldebaran. Sirius can be recognized by its brilliance; Aldebaran, a first-magnitude star, is obviously reddish. It thus resembles Betelgeux, and is in sharp contrast with the bluish-white colour of Rigel. Also of interest is the cluster known as the Pleiades or "Seven Sisters", while other bright stars of winter skies are Capella (almost overhead in January evenings), Procyon in Canis Minor, and Castor and Pollux in Gemini, the "Twins".

Unfortunately the planets are not much in evidence during the early part of 1957. Mars, so prominent during last autumn, has now receded from the Earth, and is no longer conspicuous, setting well before midnight even in January. Venus has drawn back towards the Sun, and will not be well seen until the autumn of this year. Saturn comes to opposition on May 20, so that it will be observable by March, but it lies so far south of the celestial equator that British and United States observers will have difficulty in doing useful work. Jupiter, however, reaches opposition on March 17, when its magnitude will be −2·0 and its apparent diameter over 44 seconds of arc. It lies in the constellation Virgo, and can be recognized at once by its great brilliancy, which far exceeds that of Sirius or any other star. In March it will of course lie approximately south at midnight, and any small telescope will suffice to show its main surface features and its four major satellites.

FIG. 1.

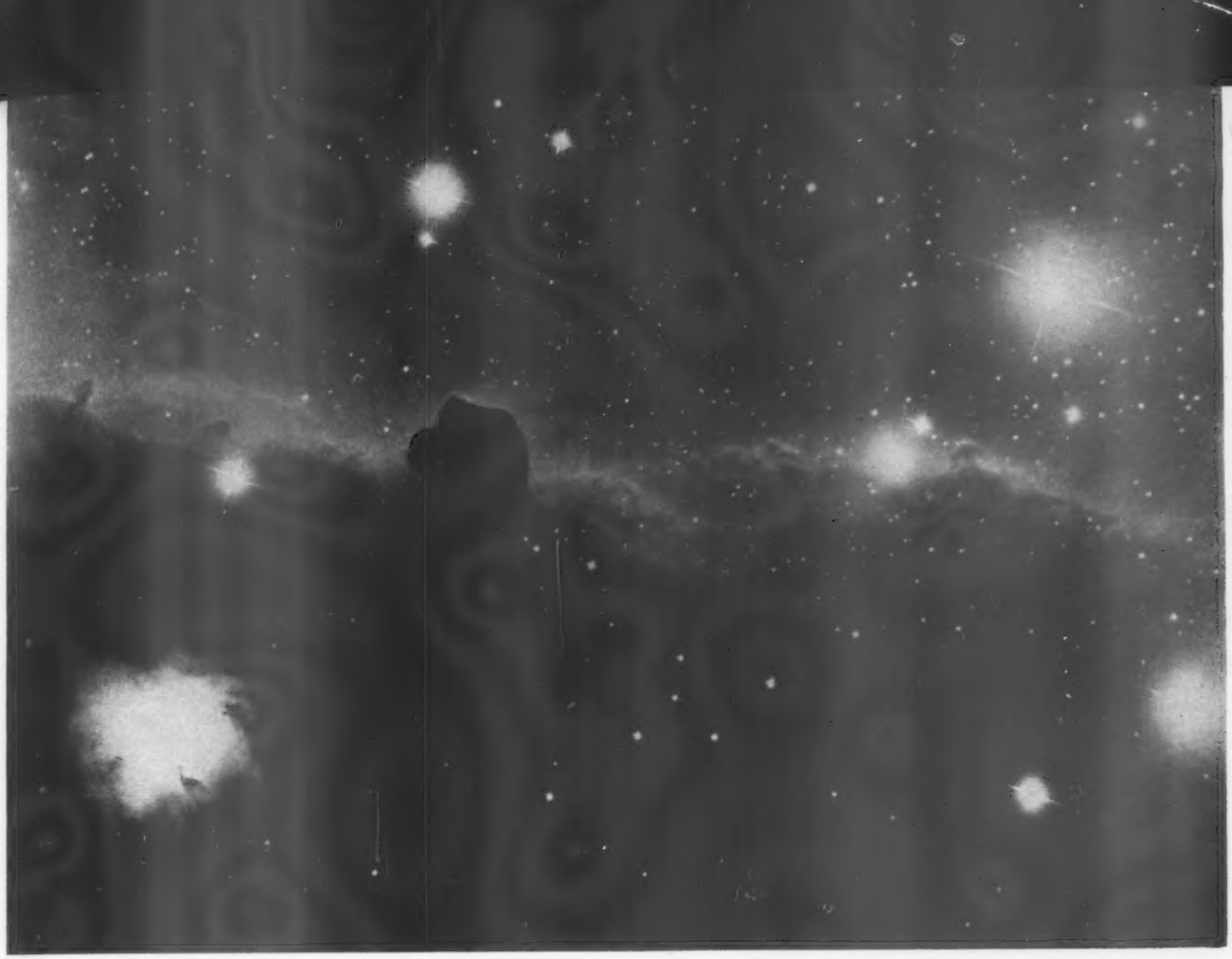


FIG. 2.

The International Lunar Society

Many amateur, some professional astronomers and everyone concerned with space-flight must be interested in the Moon, since it will inevitably be the first celestial body to be reached. To increase our knowledge of the Moon, and to correlate the work of lunar observers all over the world without in any way clashing with existing organizations, an International Society has been founded. It is a means by which observers of various nationalities can exchange information and ideas, and to make known the work being carried out in different countries.

With the exception of the Permanent Secretary, the Officers hold office for two years and are then replaced by new officers from different countries. A Journal will be issued every six months, contributions being printed in English, German and French. The first President is H. P. Wilkins, and to date (November 1, 1956) the membership roll stands at 200. Any serious lunar observer who wishes to be associated with the I.L.S. should communicate with the Permanent Secretary, Prof. A. Paluzíe-Borrell, Diputación 337, Barcelona, Spain.

H. P. WILKINS.

WELTRAUMFAHRT

The first and only German magazine on space flight, rocket engineering and astronautics

founded by

Dr GUENTER LOESER †
and HEINZ GARTMANN

is now entering its 8th year of publication.

Read the original articles of famous experts contributing to *WELTRAUMFAHRT*: Dr. U. T. Boedewadt, Rolf Engel, Prof. Dr. J. Eugster, Dr. S. Gerathewohl, Prof. Dr. H. Haber, H. H. Koelle, Willy Ley, Prof. Hermann Oberth, Dr. E. Saenger, Prof. Dr. W. Schaub, Prof. Dr. H. Strughold, a.o.

From the contents of

No. 4, Vol. VII (1956)

A Contribution to the Exploration of Mars, from a new book by W. v. Braun and W. Ley.
Note on the History of German Rocket Development Before the War, by G. Haeuseler.
The Biggest German Radio Telescope.
Rockets and Guided Missiles, by A. J. Zaehringer.
Report on the Astronautical Congress in Rome, by H. Gartmann.
Notes, News, Reviews—Profusely illustrated.

4 issues per year, 32 pages per issue, annual subscription, DM 9.60 (16/-).
Single copy, DM 2.40 (4/-) (plus postage).

UMSCHAU VERLAG,
Frankfurt am Main, Stuttgarter Strasse 20/22

If you like Weltraumfahrt, look for WELTRAUMFAHRT

Reviews

An Introduction to Rockets and Spaceflight. By Eric Burgess, F.R.A.S. Hodder & Stoughton, 1956. 96 pp. Price 12s. 6d.

Mr. Burgess has produced a neat little book in which he brings the subject of rocket propulsion into perspective, and describes the probable path of development from present-day reality to future interplanetary travel.

After describing the launching of a large rocket missile on one of the desert proving grounds, Mr. Burgess presents the basic principles of rocket propulsion and the fuels in use at the present time, in a manner that may be clearly understood even by those who are not technically minded.

There follows a description of the high-speed rocket-propelled aircraft under development, and the effect of conditions in space on the human body. After describing the many types of rocket-propelled missiles in service today, and this logical development into earth satellite vehicles, the method of establishing these vehicles in their orbits is made clear.

In the latter part of his book, Mr. Burgess shows how radio controlled missiles will probably be used for planetary probes and how they will be able to radio pictures of the surfaces encountered, to receiving stations on the Earth. After a brief exposition on the possibility of there being other forms of life in the universe, the author conjures up some rather fanciful impressions of how interstellar voyages might be accomplished; these, however, will be so far in the future that the reader may be left to form his own conclusions.

The book is well presented, and contains 38 pictures, illustrations and diagrams, which are quite well reproduced.

P. W. STONE.

The Viking Rocket Story. By Milton W. Rosen. Faber & Faber, 1956. 248 pp.

This book does not set out to be a technical treatise; it is much more a personal story, both of the Viking rocket and of the men who created it. It tells the story of how the Vikings were designed and built; it does not gloss over the setbacks and difficulties encountered, and the result is a book of absorbing interest.

Mr. Rosen became scientific officer in charge of Viking development at an early stage—in 1947—and has thus been associated with the project almost from its outset. He writes clearly and well, and the illustrations have been carefully chosen. The type is clear, and the few misprints are very minor.

J. S.

Between the Planets. By Fletcher G. Watson. London: Geoffrey Cumberlege, Oxford University Press. 188 pp., 67 plates. Price £1 10s.

This book was first published in 1941 by the Harvard University Press. A second edition appeared in 1956, and this new English impression has been brought fully up to date.

Countless books have been written about the Sun, Moon and planets, but the literature dealing with the junior members of the Solar System is much less extensive, and Mr. Watson's work is therefore most welcome. It treats of the asteroids or minor planets, comets, and meteoric astronomy, and includes a chapter upon what the author calls "interplanetary material"—such as the particles which produce the phenomenon known as the Zodiacal Light. The approach is basically non-technical inasmuch as the whole book can be understood by a reader with no previous knowledge, but it is felt that the information contained in it will also be of value to the expert.

Over half the book is devoted to meteors and meteorites, which are of particular interest from an astronautical point of view, and every aspect of the subject is discussed; for instance, there is a chapter dealing with meteor investigations by radar.

The author writes clearly; the print and production are good, and the plates well reproduced. The book may be strongly recommended.

P. A. C-M.

Jules Verne, Master of Science Fiction. By I. O. Evans. Sidgwick & Jackson. Price 12s. 6d.

To Interplanetarians, Jules Verne (1828–1905) will always be the man who shot his fictional space-travellers to the Moon in a hollow shell from a vast cannon which would have killed them the moment it was fired. Yet Verne was always sensitive to criticism of his scientific accuracy. Playing safe, he left the calculations of the Moon voyage to his cousin, Professor Garcet, a mathematician.

Despite the equations, air resistance would have crushed the shell ere it left the barrel.

Yet Verne had conceived the idea of fixing rockets to the shell to brake its fall to the Moon. It still seems a shame he hadn't thought of using them to give the initial impetus.

Extracts from *Round the Moon*, as well as from 14 more of Verne's imaginative romances, are gathered by I. O. Evans in *Jules Verne, Master of Science Fiction* (Sidgwick and Jackson, 12s. 6d.), each with descriptive notes and comments. All the famous titles are included, as well as less familiar ones like *The Child of the Cavern*, *The Steam House*, and *Hector Servadac*.

In *The Begum's Fortune* the launching of an artificial satellite is described. It is a purely accidental launching, and indeed, a miraculous one, for the projectile's speed is only 450 m.p.h.—unless there is an error in translation.

As Mr. Evans says in his interesting and informative Introduction, Verne tended to defeat his own ends by overloading his stories with data. Where Wells was content to suggest, the Frenchman sought to convince the reader (often to the point of tedium) with barrages of facts. And so many of the "facts" were not.

Nevertheless, his invention was prodigious. He anticipated helicopters—*The Clipper of the Clouds*, made of compressed paper and driven by electricity, is still unmatched in performance. The modern atomic submarine, *Nautilus*, is cramped compared with Verne's original, which had space for a library of 12,000 books, an art gallery, a museum, and a pipe organ!

Mr. Evans, in an acute comparison between Verne and Wells, states that neither prophet foresaw the aeroplane. Actually, Wells' *When the Sleeper Wakes* (1899) contains descriptions of aeroplanes proper, including even troop-carriers.

If one merely skims the pages that really belong in an outdated encyclopædia, most of Verne's novels remain very readable. The dialogue is crisp and often sardonically witty, the narrative has action and surprise twists. The stories are sometimes implausible but seldom fail to entertain. This representative selection may well whet the appetite of newcomers to Verne's work and send others of us back to it to recapture old delights.

W. F. TEMPLE.